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Bovine Tuberculosis in Children

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THIS investigation was begun in March, 1926, under the auspices of the National Research Council of Canada, and is being continued at the present time. The purpose of this study was to determine (1) the incidence of bovine tuberculosis in children, (2) the role played by milk in the transmission of this disease, and (3) the effect of preventive measures, namely, the eradication of tuberculosis in cattle by tuberculin testing and slaughter of reacting animals, and the more widespread use of pasteurization of milk upon the incidence of this disease in children.

As pointed out in previous communications, this investigation is being carried out in the city of Toronto, where pasteurization of milk is compulsory, and where it has been rigidly enforced since 1915, thus affording us an excellent opportunity for study of the efficacy of such a procedure in controlling milk-borne infections.

With the co-operation of the various city hospitals, and the Hospital for Sick Children in particular, we have been enabled to study a large number of tuberculous children from Toronto, as well as children admitted from different parts of the Province of Ontario, other Provinces and other countries from which we have obtained materials for the purpose of determining the type of infecting organism. In addition, through private physicians and sanatoria we have had contact with a considerable number of tuberculous children throughout the Province.

Correlating the clinical with the laboratory findings in a large number of tuberculous children studied, we find that primary pulmonary or tracheo-bronchial tuberculosis in a child is invariably caused by the human type of the tubercle bacillus. Extra-pulmonary tuberculosis in a child, in the presence of a demonstrable focus in the tracheo-bronchial glands or lung, was also caused by the human type of the tubercle bacillus. On the other hand, extra-pulmonary tuberculosis in a child, in the absence of demonstrable tuberculosis in the tracheo-bronchial glands or parenchyma of the lung, we regard as bovine in origin, until otherwise proved.

At this time of writing, in a series of 500 tuberculous children, investigated over a period of thirteen years, in 9.6 per cent. of extra-pulmonary tuberculosis the infecting organism has proved to be of bovine type. Bovine tubercle bacilli have been recovered from bones, joints, glands, kidney, meninges, serous surfaces, tonsils, adenoid tissue and skin. Thus, with the exception of primary tuberculosis of the lung, no organ or tissue of the human body is immune to infection with the bovine type of the tubercle bacillus.

The youngest patient in this group was an infant 6½ months old, suffering from bilateral tuberculous adenitis and tonsillitis, the oldest, a girl 14 years of age, suffering from renal tuberculosis, which necessitated the removal of one kidney.

Without exception, the children harbouring infection with the bovine type of the tubercle bacillus have come to Toronto for treatment from different parts of the Province of Ontario, other Provinces and other countries, where the milk supply is not pasteurized. History invariably revealed the fact that the child had been fed raw milk for some time, or had always been fed it. Wherever possible, we endeavoured to obtain milk for examination and guinea-pig inoculation. Thus, in three instances in this series it was possible not only to demonstrate tubercle bacilli in the milk consumed by the child, but to actually trace the infection to the animal responsible for the transmission of the disease to the human host.

The following case histories will illustrate these points:

1. Between 1926-1927 we encountered four cases of bovine tuberculosis of cervical glands and tonsils in children living in a suburb of Toronto. Enquiry revealed the fact that these children lived in the same neighbourhood, almost the same street, and were supplied with milk from one dairy, distributing raw milk. We communicated with the dairyman, and found that he did not own any cattle, but he bought milk from neighbouring farmers, pooled it, and sold it raw. A pint bottle of milk purchased at the time yielded tubercle bacilli on guinea-pig inoculation. We reported this condition to the Provincial Board of Health, who in turn communicated with the local Board of Health, and were instrumental in introducing pasteurization of milk in that community. We recovered two more cases of residual infection from that neighbourhood, one a case of tuberculous meningitis. There have been no new cases from that community since 1931, when pasteurization was introduced.

2. A child age 8 years, the daughter of a farmer from Todmorden, Ontario, was admitted to the hospital with a clinical diagnosis of tuberculous cervical adentitis and tonsillitis. Pus from the glands, and the tonsils removed at operation, yielded bovine tubercle bacilli. Enquiry revealed the fact that this child had all her life lived on the farm, and had always had raw milk from a mixed herd. We informed the father, a very intelligent man, that his daughter had in all probability contracted her tuberculous infection through the milk. He had his herd, comprising 13 head of cattle, tuberculin tested. Twelve of the thirteen animals reacted to tuberculin. He disposed of the animals, had them slaughtered and was present at the autopsy. All the animals were tuberculous; two animals were so grossly diseased that their carcasses were condemned. He has since

acquired and maintained a tuberculosis-free herd, and has become an ardent convert to pasteurization of milk.

3. A physician practising in a small town in Ontario brought his son, age 18 months, for diagnosis and treatment. The child was suffering from bilateral tuberculous adenitis and tonsillitis. The glands removed at operation, and the tonsils yielded bovine tubercle bacilli. Enquiry revealed the fact that the child had, for the past nine months, been fed raw milk from one cow. The father objected to pasteurized milk, claiming that pasteurization altered the nutrient qualities of the milk, and destroyed the vitamins. And furthermore, he firmly believed in the desirability of feeding the child milk from one animal. Unfortunately, this animal had advanced tuberculosis.

4. In October, 1931, we recovered bovine tubercle bacilli from the hip-joint of a child, 3 years of age, admitted from Kirkland Lake, Ont. Enquiry revealed the fact that this child had been fed raw milk from one dairy until 1930, when the city passed an ordinance making pasteurization of milk compulsory. And furthermore, in 1930, this child had had a severe attack of septic sore throat. It was interesting and significant that there had occurred in 1930 in Kirkland Lake an outbreak of septic sore throat, with 457 cases and 4 deaths. The outbreak was traced to one dairy distributing raw milk. Seven head of cattle, ostensibly tuberculin-negative, comprising the herd, were sacrificed. One animal was so grossly tuberculous that the carcass was condemned. Thus, raw milk from this particular source served not only to disseminate haemolytic streptococci, but bovine tubercle bacilli as well. It was the outbreak of acute streptococcal infection which attracted attention to the milk as the source of the infection, the insidious infection with the bovine tubercle bacillus having been completely overlooked.

On the other hand, not a single proved case of bovine tuberculosis has arisen in a group of children studied from Toronto. In other words, the generation of children brought up on pasteurized milk have escaped infection with the bovine type of the tubercle bacillus. And furthermore, there is no record of any milk-borne outbreak in this city since 1915. Thus the effective pasteurization of milk, carried out under rigid Board of Health supervision, eliminates not only bovine tuberculosis, but all milk-borne infections.

In an effort to determine the extent to which "pooled" milk is contaminated with the tubercle bacillus, and to confirm the efficacy of effective pasteurization, we examined 200 samples of pooled raw milk, which we removed from the pasteurization tanks prior to heating. We found that 26 per cent. of the samples examined yielded bovine tubercle bacilli on guinea-pig inoculation. The milk was then heated to 145°F., held at that temperature for 30 minutes, then quickly cooled to 50°F. One hundred samples of milk examined immediately after pasteurization proved free from bovine tubercle bacilli on the biological test.

Milk suffers no damage by pasteurization that is at all comparable with the risk of drinking raw milk. It does not alter the calcium or phosphorus content of the milk. It has very little effect on the vitamins in the milk. Pasteurization does not alter the taste or nutrient qualities of milk, but it does definitely make

milk safe from all pathogenic micro-organisms, including the highly resistant tubercle bacillus. Raw milk should no longer be allowed to impede the progress of public health in a community.

Since 1926, when this investigation was begun, considerable progress has been made in the Province of Ontario from the standpoint of eradication and control of bovine tuberculosis in its natural host. Of nearly 850,000 cattle tuberculin tested, 12.8 per cent. found to be reactors have been removed. Pasteurization has been introduced in many municipalities. In 1934 there were 20 municipalities in Ontario which had adopted compulsory pasteurization of milk. This was increased to 35 municipalities in 1936 and to 50 in 1938. Further, in 75 municipalities a considerable part of the milk is now pasteurized.

The decrease in the incidence of bovine tuberculosis in children, as recorded in this study, from 13.5 per cent. in 1935 to 9.6 per cent. at this time of writing, is attributable to (a) the elimination of bovine tuberculosis in cattle with its subsequent milk infection by the destruction of reactors, and (b) more important still, the more widespread use of pasteurization of milk.

From an economic point of view, the elimination of bovine tuberculosis in its natural host by tuberculin testing and slaughter of reactors is of untold value to the breeder and farmer, but from a public health point of view, effective pasteurization of milk is the ideal to strive for. For the effective pasteurization of milk eliminates not only bovine tuberculosis, but all other milk-borne infections as well.

SUMMARY AND CONCLUSIONS

1. At this time of writing, 9.6 per cent. of extra-pulmonary tuberculosis in children under 14 years of age is caused by the bovine type of the tubercle bacillus.

2. Bovine tuberculosis in children is an ingestion infection, raw milk being the vehicle for the transmission of the disease.

3. Bovine tuberculosis is preventable, and can be controlled by the effective pasteurization of milk.

4. The decrease in the incidence of bovine tuberculosis in children is attributable to gradual elimination of tuberculosis in cattle, but more important still, to the more widespread use of pasteurization of milk throughout the Province of Ontario.

5. The importance of bovine tuberculosis in a community lies not in the amount in which the disease exists, but in the ease with which it can be controlled. The excellent results obtained in the city of Toronto from the standpoint of eradication of not only bovine tuberculosis, but all other milk-borne infections as well, are attributable solely to the effective pasteurization of milk, and afford an unchallenged demonstration of the control of preventable disease in a community.

6. We believe that, by adopting universal pasteurization of milk, bovine tuberculosis in children could be eliminated in the Province of Ontario within five years.

Survey of Certain Milk-borne Diseases in Canada

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THROUGH the co-operation of the provincial departments of health, a list of outbreaks of milk-borne diseases, occurring in Canada during recent years, was compiled by the late Mr. R. H. Murray, C.E., and published in 1936. This list recorded 7,935 cases, with 688 deaths. Of this number, 7,134 were cases of typhoid and paratyphoid fevers, 584 of septic sore throat, and 192 of scarlet fever. The list records only a small part of the total number of cases of these diseases that had their origin in infected milk. Only the outbreaks that were known to the provincial departments of health were possible of inclusion.

The number of sporadic cases of milk-borne diseases undoubtedly exceeds greatly the number of cases reported in outbreaks. Further, many small outbreaks are not reported; others are not investigated, and in others the possible relationship of the outbreak to milk is not suspected. In one of the largest states in the United States, possessing a highly efficient state department of health, three outbreaks of septic sore throat occurred recently within a few months, and in each instance the epidemic had been in progress for a number of weeks before information was received by the state authorities. In one instance, 137 cases occurred between the middle of March and the middle of June; and in a second instance 200 cases occurred in a rural village during the months of May and June, but the department did not learn of the outbreak until July. If such extensive outbreaks can be "missed" in a state possessing a highly efficient department of health, it is to be expected that small outbreaks of septic sore throat, scarlet fever, or other communicable diseases transmitted by milk, may often be unreported.

The information previously presented by Mr. Murray has been supplemented by data kindly furnished by the provincial departments of health and a number of municipalities. These data are presented in table I.

Tuberculosis (of Bovine Origin)

The importance of tuberculosis of bovine origin is well recognized. In Canada definite knowledge of the incidence of tuberculosis of bovine origin has been furnished by the important studies of Price (1) during the past thirteen years. These studies have shown that 9.6 per cent. of the cases of extra-pulmonary tuberculosis in children under 14 years was due to the bovine type of tubercle bacilli. The cases were largely from Ontario. It is highly significant that all these patients had used raw milk.

TYPHOID AND PARATYPHOID FEVERS

Typhoid and paratyphoid fevers have been the most frequently reported milk-borne diseases in Canada. A serious outbreak of typhoid fever occurred in the city of Moose Jaw, Saskatchewan (2), during August and September, 1937, with a further small outbreak in November. At the time of the outbreak, 92.5 per cent. of the milk distributed was pasteurized. Under the Saskatchewan Milk Control Board there were three milk depots which were also pasteurizing plants, and five producer-distributors. Supplying the depots were 55 milk producers. There was in addition the supply from 45 privately-owned cows. Effective supervision and control of the milk supply have been maintained by the Department of Health of the city for a number of years. The cattle in all herds supplying milk to the city were tuberculin-tested, retests being made regularly under the supervision of the Dominion Department of Agriculture. Only milk from herds free from Bang's disease has been permitted to be sold. Employees engaged in the process of pasteurizing and distributing milk are required to produce medical certificates of health. The total daily consumption was estimated as 5,083 quarts.

A total of 69 cases of typhoid fever occurred, with 10 deaths. The occurrence of the outbreak is outlined in the annual report of the Medical Officer of Health, as follows (2):

"Not since the year 1914 has this city recorded so many cases of typhoid nor has this disease assumed epidemic form since that date. The milk-borne epidemic of this year is the first of which we have record.

"In January, two cases in one family, where already two deaths and five cases occurred in the last month of 1936, were reported and one of these died. The source of this outbreak was not definitely located.

"In May there were two cases in another home without evidence of contact with any preceding illness.

"Then on August 17th a patient was admitted to hospital with typhoid, who, it appeared, might have become infected from a source not within the city limits.

"Ten days later two other notifications came in followed within a week by a group of twelve, and in the following week by twenty-eight more. Inquiry showed that these were all obtaining their milk supply from a raw-milk dairy, and following the first six or eight notifications this source of milk supply was stopped, but too many had already been infected. In the thirteen days following, thirteen more cases were reported and later three others within the period of incubation from the date when this milk supply was cut off. In this group of known consumers of the suspected milk supply, there were fifty-four persons sick of which eight died.

"Again in early November there occurred a smaller outbreak of three in one household and one of these was fatal. Inquiry disclosed that milk and cream, from an unauthorized source, had been brought into the city where the person handling the milk was ill, afterwards diagnosed typhoid. Since November 7th no further notifications have been recorded.

"The progress of the epidemic, by date of onset, was:

August	2 cases	Week ending Sept. 22	8 cases
Week ending Sept. 8	11 "	Week ending Sept. 29	7 "
Week ending Sept. 15	23 "	October	6 "
Milk supply was stopped.		November	3 "

"The origin of nearly all this illness was in an area of about one half mile radius of the suspended dairy. In this area there were a number of cow-keepers, who are not milk distributors but keep a cow for family use only, and at three of these typhoid was found to be existent but there was no trace of connection with the suspended dairy, where all members of the family and employees were tested for a typhoid carrier and all gave a negative reaction."

A pasteurization by-law requiring all milk to be pasteurized was passed by the City Council.

During 1937, two outbreaks of paratyphoid fever occurred in Ontario and were traced to the distribution of raw milk. Five cases, with two deaths, occurred among the eight people who received milk from a one-cow supply. The other outbreak occurred among the consumers of a small dairy in which the utensils were not sterilized.

MILK-BORNE DISEASES DUE TO STREPTOCOCCI

The incidence of bovine mastitis varies greatly in herds, occurring in from 5 to 90 per cent. The strains of streptococci commonly responsible do not appear to produce acute infections in man. There is some evidence, however, to suggest that such streptococci of bovine origin may play some part in the occurrence of gastro-intestinal disturbances occurring among persons using raw milk, and serious outbreaks of septic sore throat or scarlet fever have followed the use of milk containing such strains of streptococci. Many small outbreaks are not recognized and the extent of septic sore throat and scarlet fever due to infected milk is not known. The outbreaks may also be of large proportions, like the epidemic of septic sore throat at Kirkland Lake, Ontario, in 1930, when 457 cases with 4 deaths were reported. That milk-borne epidemics of streptococcus infection are of frequent occurrence is evidenced by the reporting of 7 outbreaks during the 3-year period 1934-36 in New York State, comprising 1,529 cases and 24 deaths (3). Three of the epidemics, consisting of 806 cases and 16 deaths, were classified clinically as scarlet fever, and 4 epidemics, consisting of 723 cases and 8 deaths, were classified as septic sore throat. It is significant that all the epidemics occurred in centres of less than 6,000 population. In each instance the incriminated milk supply was one of raw milk or cream.

STAPHYLOCOCCAL FOOD POISONING

It is known that certain cases of bovine mastitis are due to staphylococcal infection. Gwatkin and his associates (4), in a study of 260 cattle found mastitis to be present in 143. Thirty of these they considered to be cases of staphylococcic mastitis. Staphylococci are known to be common inhabitants of the udder. In 1914 Barber (5) drew attention to the presence of gastro-enteritis following the consumption of cows' milk contaminated with a white staphylococcus. It was not, however, until 1930 that Jordan (6) demonstrated the presence of a definite enterotoxin produced by certain strains of staphylococci. The investigations of Dolman (7) confirmed the presence of enterotoxin and the introduction of an animal test by him has facilitated the investigation of this enterotoxin in foods suspected of having caused poisoning. Gwatkin and his associates (4) in 1934

TABLE I

MILK-BORNE DISEASE IN CANADA AS RECORDED BY PROVINCES AND MUNICIPALITIES 1912-1937

Year	*Municipality*	*Province*	*Disease*	*Cases*	*Deaths*
1912	Winnipeg	Manitoba	Typhoid fever	92	7
1913	Calgary	Alberta	Scarlet fever	13	0
1916	Winnipeg	Manitoba	Typhoid fever	23	0
1918	Quebec City	Quebec	Typhoid fever	23	2
1919	Winnipeg	Manitoba	Scarlet fever	73	0
1920	Regina	Saskatchewan	Typhoid fever	83	9
1921	Montreal	Quebec	Typhoid fever	5	0
1921	Bowmanville	Ontario	Typhoid fever	6	0
1921	Vinelands	Ontario	Typhoid fever	20	0
1922	Quebec City	Quebec	Typhoid fever	14	3
1922	Montreal	Quebec	Typhoid fever	33	3
1922	Winnipeg	Manitoba	Scarlet fever	29	0
1922	Winnipeg	Manitoba	Scarlet fever	10	0
1923	Saint John	New Brunswick	Typhoid fever	10	0
1923	Sherbrooke	Quebec	Typhoid fever	7	2
1923	Arnprior	Ontario	Typhoid fever	6	0
1923	Hanover	Ontario	Typhoid fever	46	4
1924	Long Branch	Ontario	Typhoid fever	13	0
1924	Montreal	Quebec	Typhoid fever	16	2
1924	Cobalt	Ontario	Typhoid fever	6	0
1924	Quebec City	Quebec	Typhoid fever	8	0
1924	Quebec City	Quebec	Paratyphoid fever	5	0
1925	Winnipeg	Manitoba	Scarlet fever	28	0
1925	Winnipeg	Manitoba	Typhoid fever	9	2
1926	Winnipeg	Manitoba	Typhoid fever	15	0
1927	Montreal	Quebec	Typhoid fever	5,002	533
1927	Chatham	Ontario	Typhoid fever	109	7
1927	Quebec City	Quebec	Typhoid fever	12	0
1928	Quebec City	Quebec	Typhoid fever	20	4
1928	Dundas	Ontario	Typhoid fever	13	0
1928	Timmins	Ontario	Typhoid fever	10	0
1928	Sturgeon Falls	Ontario	Typhoid fever	12	0
1928	Lake Scugog	Ontario	Typhoid fever	3	1
1929	Edmonton	Alberta	Scarlet fever	28	0
1929	Ameliasburg	Ontario	Typhoid fever	17	2
1930	Belleville	Ontario	Typhoid fever	18	3
1930	Kirkland Lake	Ontario	Septic sore throat	457	4
1930	S. Westminster	British Columbia	Typhoid fever	14	1
1930	Montreal	Quebec	Typhoid fever	130	26
1930	Montreal	Quebec	Typhoid fever	96	12
1931	Kitchener	Ontario	Scarlet fever	11	0
1931	St. Catharines	Ontario	Paratyphoid fever	487	3
1931	Surrey	British Columbia	Typhoid fever	14	1
1931	Hampton	New Brunswick	Typhoid fever	7	0
1931	La Pérade	Quebec	Typhoid fever	29	2
1931	Dauphin	Manitoba	Septic sore throat	100	0
1932	St. Maurice Valley	Quebec	Typhoid fever	527	45
1933	St. Catharines	Ontario	Paratyphoid fever	30	0
1933	Carman	Manitoba	Typhoid fever	15	1
1933	Port Elgin	Ontario	Septic sore throat	27	0
1933	Kingston	Ontario	Typhoid fever	19	0
1933	St. Eustache	Quebec	Typhoid fever	27	2
1934	Moose Jaw	Saskatchewan	Undulant fever	21	0
1934	Edmunston	New Brunswick	Typhoid fever	12	0
1934–35	Shawinigan Falls	Quebec	Typhoid fever	59	5
1935	Minnedosa	Manitoba	Undulant fever	4	0
1929–36	Ontario (Province)		Undulant fever	758	0
1936	Spring Bank	Alberta	Typhoid fever	4	0
1936	Thorsby	Alberta	Typhoid fever	9	0
1936	Edmonton	Alberta	Typhoid fever	9	0
1937	Vancouver	British Columbia	Undulant fever	15	0
1937	Edmonton	Alberta	Undulant fever	7	0

TABLE I—*continued*

Year	*Municipality*	*Province*	*Disease*	*Cases*	*Deaths*
1937	Moose Jaw	Saskatchewan	Typhoid fever	69	10
1937	Rosthern	Saskatchewan	Typhoid fever	4	0
1937	Saskatchewan (Province)		Undulant fever	7	0
1937	Manitoba (Province)		Undulant fever	7	0
1937	Ontario (Province)		Undulant fever	104	0
1937	Watford	Ontario	Paratyphoid B	12	1
1937	Bayfield	Ontario	Paratyphoid B	5	2
1937	Black Lake	Quebec	Typhoid fever	6	3
1937	Plessisville	Quebec	Paratyphoid B	18	1
1937	Quebec (Province)		Undulant fever	38	0
1937	Plaster Rock	New Brunswick	Undulant fever	4	0
	Total			8,999	703

OUTBREAKS ACCORDING TO DIAGNOSIS

	Outbreaks	Cases	Deaths
Typhoid fever	47	6,701	692
Paratyphoid fever	6	557	7
Scarlet fever	7	192	0
Septic sore throat	3	584	4
Undulant fever	—	965	0

showed that 67 per cent. of the strains recovered from cases of mastitis and 20 per cent. of the strains from normal udders produce toxin. The work of Davis (9) indicates that the udder is not as readily infected with staphylococci of human origin as with human strains of haemolytic streptococci. However, when staphylococci of human origin were injected into the lactiferous duct, mastitis followed. Crabtree and Litterer (8) traced an outbreak of 242 cases of food poisoning to a toxin-producing haemolytic staphylococcus obtained from the udders of cows suffering from mastitis. During the past few years several other outbreaks of food poisoning have been found to be due to contamination with toxin-producing staphylococci. In each instance the poisoning has been associated with milk or cream products. In the majority of outbreaks studied, unpasteurized milk or cream was used. The origin of the toxin-producing strains of staphylococci was found to be either bovine mastitis of staphylococcic origin or subsequent contamination from human sources. The occurrence of such food poisonings is further reason for the pasteurization of all milk supplies.

BRUCELLOSIS

The reporting of cases of undulant fever in the United States in 1928, and shortly afterwards in Canada, gave an added impetus to the efforts to require the pasteurization of public milk supplies. Information relating to dairy herds in various parts of Canada indicated that in some herds a high percentage was infected with contagious abortion while in other herds the percentage was small. In 1929 the Health of Animals Branch of the Dominion Department of Agriculture inaugurated a control plan making it possible for the owner to establish herds free from this infection.

The incidence of contagious abortion in Canada varies in different districts, being higher among herds situated near cities where there are frequent changes in the herds and lowest in rural areas where cattle are bred for stock. In Ontario a survey made by Gwatkin of the cattle in 22 herds, comprising 1,140 animals, 345 (30.5 per cent.) gave a positive reaction on testing and in 75 (6.6 per cent.) the tests were considered suspicious. In contrast, Marriott (10) reports that in the fall of 1937 testing of 16,511 dairy cattle from the dried-out areas of western Canada showed only 1.57 per cent. of the animals to be positive.

Although the economic loss occasioned by contagious abortion in cattle is very great and its occurrence constitutes a very serious problem to the dairy industry, progress of control measures has been relatively slow. The lack of compensation to owners of infected cattle requiring to be slaughtered, the cost of securing abortion-free stock, and the problem of maintaining clean herds, have constituted serious difficulties.

In the ten years that have elapsed since the first case was described in Canada, only a small number of cases have been reported to the provincial departments of health. As a result, there has been a tendency to question the danger of the transmission of this disease to man. The low incidence of the disease, particularly in children who are naturally the consumers of the largest quantity of milk, has raised problems. The essential facts concerning the relationship of contagious abortion in cattle and brucellosis in man are, however, established.

In a recent study of the question of the low incidence of clinical cases in spite of widespread exposure, particularly in urban areas in which the sale of raw milk is permitted, Anderson (11) has pointed out that it is probable that the majority of persons develop not an acute attack of the disease but suffer an infection too slight to cause symptoms requiring a physician's attention. Only the acute clinical cases are studied. Alice Evans (12), in a discussion of this subject, speaks of the occurrence of many chronic cases with symptoms suggesting neurasthenia, having little or no fever or other symptoms of acute brucellosis. Investigation of persons employed in slaughter houses has shown that many present positive serological findings indicating Brucella infection but on inquiry give no history of illness. Such a finding supports the view that mild infections occur which immunize rather than produce acute illness.

In the table of recorded cases of milk-borne diseases, it is seen that in several provinces special attention is being given to brucellosis. In all the provincial laboratories facilities are provided for the examination of blood samples, and in several the examination of all samples submitted for the Widal test is made. In this way information is being obtained concerning the incidence of this disease and physicians are advised of the findings.

An important contribution has been made to this subject in the study of Dolman and Hudson (13) as relating to brucellosis in and around Vancouver. For the past six years all blood specimens submitted to the laboratories for Widal tests have been examined for the presence of Brucella agglutinins and for two

years the Brucella agglutinin titre of the whey in raw-milk samples submitted for bacterial plate counts has been made.

According to the latest official statement, 78 per cent. of the milk distributed in Vancouver is pasteurized and 22 per cent. is consumed raw. The latter is supplied through 55 licensed raw-milk distributors. During the six-year period more than 5,000 sera were tested and the incidence of positive samples was 4.5 per cent. In very few of the 5,000 sera tested was a provisional diagnosis of brucellosis made. A study of the limiting Brucella agglutinin titres of the 228 positive human sera suggests that about 42 of this group probably had an acute attack of brucellosis at the time, while at least 64 must have had a fairly recent attack. The authors point out that over 90 per cent. of the specimens were from patients living in or immediately adjacent to Vanvouver. In contrast, in a similar study of 352 specimens from residents of a town remote from Vancouver, only 2 specimens (0.57 per cent.) were positive. The incidence of Brucella agglutinins in the Vancouver group was roughly eight times that in the other group. The laboratory findings were communicated to the physicians and 15 cases of undoubted acute brucellosis were diagnosed on both laboratory and clinical grounds. In every case the evidence pointed to raw-milk consumption as the source of infection.

No more conclusive demonstration of the transmission of this disease to man can be desired than that which is recorded in this study. The authors report that the micro-organism was readily isolated from the blood of one patient. "On two occasions separated by an interval of several days a bottle of milk from the dairy which had recently supplied this patient was purchased over a shop counter. A micro-organism was readily isolated from each sample having the identical characteristics of the strain isolated from the patient." *Brucella abortus* was readily isolated from the milk of 6 dairies, of which 4 were distributors. No further information is necessary to establish the transmissibility of this disease to man and therefore the inherent need for the pasteurization of all milk. Many subacute chronic types of brucellosis undoubtedly occur. The conduct of careful clinical and laboratory studies in communities supplied with raw milk from Brucella-infected herds must be made before definite statements can be made as to the incidence of the clinically milder varieties of the disease, but in the absence of such data there is every reason for the adequate safeguarding by pasteurization of all milk supplies.

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Bovine Tuberculosis in Canada

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THE work conducted by the Health of Animals Division of the Dominion Department of Agriculture, is for the benefit of the live-stock industry, but it has also a definite relation to public health.

The progress in the control of bovine tuberculosis in Canada, which began with the offer of free testing of cattle in 1897, has gained momentum until at the present time approximately one-third of the cattle of Canada is under supervision for the control of tuberculosis and practically all cattle supplying milk to large centres of population have been tuberculin-tested. This involves the testing of over one million cattle each year.

The testing of cattle with tuberculin is on a voluntary basis. Application must be made by the cattle owners and in the case of individual herds the owners must sign an agreement. In areas two-thirds of the cattle owners must sign a petition and it is only after the area is established and gazetted that testing becomes compulsory.

Three plans are available for the control of tuberculosis in cattle.

Supervised Herd Plan

Any owner may have his cattle tested with tuberculin under this plan. An agreement is signed providing that all reactors must be slaughtered. No compensation is paid. That this plan has met with approval is indicated by the fact that 49,643 herd owners have taken advantage of it.

Accredited Herd Plan

An accredited herd is one which has passed two clean tests with an interval of one year or, if reactors are found, three clean tests at intervals of six months. After reactors are removed, the herd is retested in sixty days and if clean is retested in six months and again in six months' time. All reactors must be slaughtered under supervision and compensation is paid in accordance with the regulations. This plan is restricted to pure-bred breeding herds. The owner must be in possession of at least five pure-bred registered cattle and the pure-bred cattle must constitute one-third of the herd. Before an Accredited Herd certificate is issued, the owner must have ten pure-bred registered cattle. There are now 9,236 herds under this plan, 8,172 of which are fully accredited.

Restricted Area Plan For the Eradication of Bovine Tuberculosis

Areas are usually counties or other well-defined districts. Before an area is established, two-thirds of the cattle-owners must petition the Provincial

Minister of Agriculture who, if he approves, requests the Federal Minister of Agriculture to establish the area. If acceptable, the area is gazetted and tuberculin-testing and slaughter of reactors under supervision become compulsory. Compensation is paid for reactors. No cattle may enter an area unless a satisfactory certificate of tuberculin testing is furnished. An exception is made of cattle brought in for immediate slaughter on approved premises or feeder cattle for test at destination. When infection is reduced to ½ per cent., the area is not retested for three years and if infection is reduced to 0.2 per cent. an interval of six years is allowed before a retest is made. When infection is reduced to 0.5 per cent. the areas are known as accredited areas.

The same principle is followed in eradicating tuberculosis under each plan. All the cattle in a herd are tested and if reactors are found, another test is conducted in sixty days. Retesting is repeated at sixty-day intervals until the herd is clean. After the herd is clean, an interval of six months is allowed to elapse before a retest is made.

Each time reactors are removed for slaughter, the premises are thoroughly cleaned and disinfected with an approved disinfectant under supervision. Before compensation is paid, a report of the disinfection, an order for slaughter and a certificate of valuation and slaughter must be received. The reactors are identified on arrival at the packing establishment by a numbered ear tag and all reactors also have the letter "T" punched in the right ear. The post-mortem lesions are recorded and the extent of infection in any individual reactor can be easily ascertained.

Care is taken to prevent re-infection of the herd. All cattle must have passed a satisfactory tuberculin test on the premises of origin. They are then isolated on the purchaser's premises and retested after sixty days before being permitted to mingle with the clean herd. The feeding of animals on by-products from cheese factories, skimming stations and butter factories is prohibited unless these by-products have been sterilized by heat. The owner is carefully instructed to prevent contact of his animals with others, by abstaining from breeding operations with untested cattle and to arrange his pasture so that contact does not occur through a single fence.

All the cattle in Prince Edward Island have been tested three times since 1925. Infection found on the last test in 1937 was 0.2 per cent.

The cattle in Nova Scotia, excluding those in Cape Breton, were tested in 1927 and 2.3 per cent. of infection found. Difficulties experienced in this province have prevented a general retest of the cattle.

In New Brunswick all cattle have been tested and 2.2 per cent. of reactors were found. In nine counties infection has been reduced to ½ per cent. or less.

In Quebec 1,031,616 cattle have been tested: 655,692 of these are within restricted areas, 311,304 under the supervised herd plan, and 64,620 under the accredited herd plan. The total number of reactors removed and slaughtered represents 14.8 per cent. In fifteen counties infection has now been reduced to 0.5 per cent. or less.

In Ontario 833,145 cattle have been tested: 605,457 under the area plan, 45,168 under the supervised herd plan, and 182,520 under the accredited herd plan. The total of reactors removed is 12.8 per cent. Infection in four counties and the district of Kenora has now been reduced to 0.5 per cent. or less.

In Manitoba 212,576 cattle have been tested: 173,390 under the area plan, 30,456 under the supervised herd plan, and 8,730 under the accredited herd plan. The total of reactors represent 7.7 per cent. One municipality is accredited, that is infection is reduced to less than 0.5 per cent.

In Saskatchewan 293,093 cattle have been tested: 114,029 under the area plan, 173,724 under the supervised herd plan, and 5,340 under the accredited herd plan. Total reactors removed from infected herds in Saskatchewan amount to 1.4 per cent. Fourteen municipalities now have less than 0.5 per cent. of infection.

In Alberta no areas are established, but 41,796 cattle have been tested: 4,380 under the accredited herd plan, and 37,416 under the supervised herd plan. The reactors slaughtered amount to 3 per cent.

British Columbia has had a total of 70,598 cattle tested. There is a large area in the Fraser Valley in which 66,746 cattle have been tested. Under the accredited herd plan 3,480 cattle have been tested and under the supervised herd plan, only 372. The total number of reactors removed in British Columbia represents 10 per cent. of the cattle tested. Infection in the Fraser Valley area has now been reduced to 0.2 per cent.

As a result of the testing carried out there appears to have been a steady decline in the incidence of infection. *At the present time the extent of bovine tuberculosis in Canada does not exceed 3 per cent.* During the five years 1924 to 1928 nearly five million cattle were slaughtered under Federal inspection. When the tuberculin reactors sent for slaughter from the field were deducted the percentage of infection was 3.14 per cent. Over half a million cattle tested in various areas throughout Canada revealed 4.86 per cent., and over half a million tested in individual herds had over 12 per cent. reactors during the same period. The average of infection in these six million cattle is approximately 4 per cent. and it was estimated that infection in Canada did not exceed 5 per cent.

From 1929 to 1935 over seven and a half million cattle were slaughtered under inspection and on the same basis approximately 2 per cent. showed infection with tuberculosis. There were approximately 4,000,000 cattle tested with tuberculin under the various policies up to March 31, 1935, and of these 6.7 per cent. were reactors to the initial and subsequent tests. The total number of cattle showing tuberculosis when slaughtered under inspection for food and the reactors to tuberculin tests in the field total 419,000 or 3.6 per cent.

During the two years ending March 31, 1937, 2,936,298 cattle were slaughtered in establishments under Federal inspection. When the reactors from tuberculin testing in the field (all of which are slaughtered under inspection) are deducted, the number of cattle showing tuberculosis infection is approximately 1.7 per cent. During this period 2,148,565 cattle were tested

throughout the country in individual herds and in restricted areas and 55,985 reactors were slaughtered, or 2.6 per cent. Many of these cattle, however, have been previously tested so that this percentage is not an indication of the infection remaining in the whole country. In new areas which had been established 859,374 cattle were tested for the first time and approximately 4.2 per cent. were found infected. The average infection shown from these figures is under 2.5 per cent. and they indicate a definite decline in bovine tuberculosis in Canada.

All cattle have been tested in the following provinces and counties. Those in italics are accredited; that is, infection has been reduced to ½ per cent. or less. These accredited areas include 822,852 cattle, approximately 10 per cent. of the cattle in Canada.

Prince Edward Island: *Whole province accredited.*

Nova Scotia excluding Cape Breton Island.

New Brunswick: The counties of Charlotte, Kings, *Queens,* St. John, *Sunbury, York,* Westmoreland, Albert, Carleton, *Victoria, Madawaska, Kent, Gloucester, Northumberland* and *Restigouche.*

Quebec: *Beauharnois, Chateauguay, Huntingdon,* Chambly, *Laprairie, Napierville,* Richelieu (west of Richelieu river accredited), *St. Johns,* Vercheres, *Brome, Missisquoi, Iberville,* Rouville, Shefford, *Sherbrooke,* Stanstead, Jacques Cartier, Laval, *Richmond* (west of St. Francis River), Richmond (east of St. Francis River), Vaudreuil, *Soulanges, Lake St. John,* Chicoutimi, *Argenteuil, Compton,* Two Mountains, L'Assomption, Terrebonne, Drummond, Bagot, Saguenay (north of Saguenay river), Wolfe (not complete), St. Hyacinthe, Yamaska, Nicolet, *Pontiac.*

Ontario: Carleton (four townships accredited), *Prince Edward,* Prescott, Glengarry, *Stormont,* Russell, Dundas, Grenville, *Leeds,* Frontenac (Pittsburgh township), Manitoulin Island, *District of Kenora,* Halton, Peel, Northumberland, York, Ontario, Durham, District of Temiskaming, Peterborough and District of Thunder Bay.

Manitoba: Rural municipalities of Dufferin, Roland, Grey, Thompson, Portage la Prairie, Stanley, Pembina, Rhineland, *Winchester,* Morris, Louise, McDonald, Cartier, Lorne, St. François Xavier, Roblin, Arthur, South Norfolk, Turtle Mountain, Morton, St. James, Fort Garry, Tuxedo, Strathcona, St. Vital, Riverside, Victoria, South Cypress, Brenda and Argyle.

Saskatchewan: Rural municipalities of Longlaketon, McKillip, Millington, Last Mountain Valley, Mount Hope, Wreford, *Cupar, Lipton, Tullymet, North Qu'Appelle, Abernethy,* Wood Creek, Big Arm, *Dundurn, Montrose, Blucher, Cory, Vanscoy, Warman, Park,* Lumsden, Sherwood, Edenwold, South Qu'Appelle, Indian Head, Wolseley, *Morris* and Lost River.

British Columbia: *Five thousand six hundred square miles in the Fraser Valley District extending from Vancouver to Chilliwack.*

Infectious Abortion of Cattle in Canada

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AMONG the diseases of animals communicable to human beings, Bang's disease ranks high. From an economic standpoint it is of first importance and it is this phase of the problem with which I wish to deal.

The disease has been known over four hundred years and is more or less prevalent all over the world. The menace to public health through the occurrence of undulant fever in man, and the loss to the stock breeder directly, and more recently through the restrictions placed by other countries against the importation of cattle unless certified free from this disease, make it one of the most serious problems facing the live-stock industry. The causative agent is known. In 1896 Professor Bang of the University of Denmark isolated from an animal about to abort, an organism to which the name ***Brucella abortus,*** or Bang's bacillus, has been given. In the control of the disease, drugs have not been found of value. Vaccines were thought by many workers to offer a solution to the problem but extensive experimental trial has not demonstrated any value; in fact, the indiscriminate use of vaccines containing living organisms has been responsible for the production of the disease in many herds that might otherwise have escaped infection. There is, however, considerable experimental work in progress in the United States, Canada, and other countries, with the so-called calfhood vaccination. In this work calves from four to eight months of age are inoculated with a living strain of ***Brucella abortus*** of low virulence in the hope of producing a lasting immunity. However, before this can be recommended, controlled experiments over a number of years will be necessary.

At present the only satisfactory and reliable method for identifying infected animals is the serological test. On this is based the control policy of the Health of Animals Division of the Dominion Department of Agriculture. This policy has been in effect since 1929 with encouraging results in eradicating the disease in infected herds and in maintaining them free from infection. To be eligible for assistance the herd must be dealt with under either the Accredited, Supervised, or Restricted Area plans for the control of tuberculosis. The owner must sign a form agreeing to have blood samples submitted from all his cattle at stated times for examination by a Dominion Laboratory. He must not allow them to come in contact with others of a lower health status. All milk or milk products fed to calves must be from healthy cows or have been pasteurized by heating to not less than 150° F. for twenty minutes. All animals giving positive reactions must be maintained on the premises until they have been permanently

marked. All additions to the herd must have passed a satisfactory official test before being brought on the premises. They must be strictly isolated until a further test is made not less than thirty days before being added to the herd. The owner must also agree to carry out advice given by officials of the Health of Animals Division in regard to isolation, segregation, cleaning, and disinfection for the purpose of preventing the spread of infection and to make no claim for compensation for animals disposed of by slaughter nor for any injury or loss sustained in connection with any animals under test. The policy is a voluntary one between the live-stock owner, the local veterinarian, and the Department. The local veterinarian through his daily contact with his clients is in the best position to advise them on the many points necessary to prevent infection being introduced from outside sources and in dealing with it should it gain entrance. It was for this reason that owners are required to employ the services of a qualified veterinarian to take the blood samples. The Department supplies free of charge sterile vials and conducts the examination of the blood at the laboratories by experienced pathologists.

The owner and the veterinarian are furnished with a copy of the report of the test. In the event of any infection being shown, one of the regular veterinary inspectors visits the premises and carefully discusses the problem with the owner, giving him any advice possible regarding the proper disposal of infected animals and contact material and the proper cleaning and disinfection of the premises.

No compensation is paid when animals giving a positive test are slaughtered. The regulations made under provisions of the Animal Contagious Diseases Act require the permanent marking of all reactors to an official test except unbred yearlings and calves. The official mark is the letter "B" tattooed in the right ear. Herds are dealt with under either the single or double unit plan.

The *single-unit plan* calls for removal of all infected animals from the premises, which are then thoroughly cleaned and disinfected with lime wash to which has been added the requisite amount of a registered disinfectant. All manure and refuse must be removed and the yard treated with lime.

The *double-unit plan* requires the infected animals to be removed from the negative herd and strictly isolated. The premises must be cleaned and disinfected as outlined in the single-unit herd. The great majority of herd owners prefer the single-unit plan except in cases where the infected animals are of exceptional breeding value and it is considered advisable to retain them in an endeavour to produce a healthy herd, after which they may be disposed of for beef. This plan requires the greatest care on the part of the owner to prevent infection being carried from the infected to the negative herd. If possible they should be attended by separate attendants, and separate utensils, such as drinking utensils, forks, shovels, and brushes, are required. All calves from the infected herd being raised for breeding purposes must be removed at birth to entirely separate quarters and fed milk from negative cows. After ninety days they must pass a satisfactory test before being taken to the premises where the negative herd is kept.

When the initial test of the herd is negative, a retest should be made in three months. If this is also negative, a third test should be made in nine months—a year having elapsed from the date of the initial test. Should infection be found on the initial or subsequent retests, the retests should be made at intervals of from thirty days to six weeks until a negative test is obtained. Thereafter two tests are made at intervals of three months, and a further test at six months.

When a herd has passed three or more negative tests at an interval of a year, the owner may request a serological test to be made, the blood samples being taken by a veterinary inspector of the Department. If this examination shows the entire herd to be negative, the herd is listed as free from Bang's disease and is tested annually by the Department, or more frequently should it be considered necessary.

The freeing of herds from Bang's disease is of the greatest value to the producers, to the consumers of dairy products, and to the whole country. An infected animal is unprofitable to the owner because it produces less milk. It is, as well, a serious menace to the health of consumers of raw milk. The value of negative herds is evidenced by the trend of public opinion. Until now the policy has been confined to the single-herd plan with the exception of assistance furnished several breeders' clubs in Nova Scotia where a campaign was started in 1932 in Annapolis County and later extended into Yarmouth County. The local authorities planned the effort and arranged with the local veterinarian to take the blood samples. They also arranged for the disposal by slaughter of positive animals. Each herd owner signed the regular agreement form. The great advantage of such an area method of control is the testing of all herds in the district and the freeing them from infection, thereby greatly lessening the chances of re-infection. Further, the work is conducted more expeditiously since re-infection from untested infected herds in the vicinity is minimized. The cost of collection of blood samples is also much lower. It is hoped that in the near future the work may be conducted on an area basis in other parts of the country. Many requests have been received from breeders and it is hoped that in the near future the work may be conducted on an area basis plan.

Breeders of cattle are demanding assurance that animals added to their herds are healthy, and foreign countries are making their import regulations increasingly stringent. Experience has shown that one test of an animal is not sufficient. A knowledge of the health status of the entire herd is necessary. Hence many markets have been closed to all but cattle from herds listed as free from Bang's disease. All dairy and breeding cattle for export to Great Britain must be from herds fully accredited for tuberculosis and listed as free from Bang's disease, or shall have passed satisfactory tests within sixty days of shipment. These tests are made by the Health of Animals Division free of charge.

In order to facilitate the export to the United States and reduce delay in getting the results of blood tests to meet various requirements, arrangements were made through the co-operation of provincial public health laboratories. To

assure uniform results antigen is supplied and a standard technique is followed in the examinations and in the interpretation of the results. All dairy and breeding cattle for export to the United States six months of age or over, with the exception of steers and spayed heifers, must have passed an official test within a period of sixty days. In addition many State regulations require a certificate that the herd from which animals originate has passed one or more negative official tests and others will accept only cattle certified by the Health of Animals Division as being from herds listed as free from Bang's disease.

At the laboratories of the Health of Animals Division, Ottawa, the slow agglutination (tube) test is employed as routine. The rapid agglutination (plate) test and the complement-fixation test are used as confirmatory tests. In this way, samples may be classed either as negative or positive. In cases where this is not feasible, the sample is marked questionable and the owner is asked to isolate the questionable animal and have a further blood sample forwarded for retest after a period of six weeks.

The question is often asked: What is the incidence of Bang's disease in cattle in Canada? No general answer can be given. The incidence varies according to the district and the type of breeding. Naturally areas adjacent to cities, where large quantities of milk are required and the replacement of cows is rapid, show the greatest incidence, whereas districts farther from markets, breeding cattle for sale, have a very low infection. In the fall of 1937, out of 16,511 dairy cattle from the dried-out areas tested, the percentage of positive animals was 1.71. The average in all herds under supervision in the Dominion was 2 per cent.

On May 1st, 1938, 1,601 herds representing 44,828 cattle were under supervision. Of this number of herds, 2 were in Prince Edward Island, 110 in Nova Scotia, 6 in New Brunswick, 113 in Quebec, 1,332 in Ontario, 4 in Manitoba, 19 in Saskatchewan, 2 in Alberta, and 2 in British Columbia. Five hundred and three herds were recorded as free from Bang's disease, 17 being in Quebec and 486 in Ontario.

THE CANADIAN MEDICAL ASSOCIATION AND COMPULSORY PASTEURIZATION*

WHEREAS raw milk may be the means of transmitting various types of serious infectious diseases such as bovine tuberculosis, typhoid fever, undulant fever, scarlet fever, diphtheria, septic sore throat, etc., and is a major factor in high infant mortality; and

WHEREAS it has come to our attention that there are many areas in Canada where raw milk is still distributed and sold;

BE IT RESOLVED that this Association go on record as endorsing the compulsory pasteurization of all milk offered for sale.

**Resolution passed at the annual meeting held in Ottawa, June, 1937.*

The Changing Methods for the Quantitative Estimation of Bacteria in Milk

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THE three principal methods of estimating quantitatively the bacterial content of milk, *i.e.*, the plate and Breed counts and the methylene blue reduction test, have undergone little change from the original techniques. This would seem to imply that these tests have been completely satisfactory in their classical forms. Such, however, has not been the case and recent years have witnessed important modifications either adopted or proposed. The present paper is a brief review of some of the more important of these changes with their resultant bearing on interpretation. Space limits preclude any pretense of exhaustiveness.

The Plate Count

The beef-extract-peptone medium introduced from water bacteriology into milk control laboratories on both sides of the Atlantic was early recognized as failing to support the growth of many species of bacteria commonly found in milk such as the common milk-souring bacteria. Some held this to be immaterial since the common milk-souring bacteria are not pathogenic. Such a view was considered fallacious by others on the ground that many of the common pathogens themselves fail to grow on the medium and in any case routine interpretations are strictly quantitative and in no way qualitative. As the purpose of a routine quantitative test has gradually emerged with greater clarity, there seems to be almost unanimous agreement in favour of a more adequate medium.

The addition of a fermentable sugar to the plating medium has long been recognized as broadening the scope of the plate count. There is international agreement, at least between England and this continent, that the presence of skim milk or skim milk powder, results in higher counts and larger, more easily seen colonies (26, 27). There is no such agreement as to the most desirable peptone (1, 5, 26). Hydrolysed casein (tryptone) is growing in favour on this continent (3, 5) but Wilson (26) found a casein-digest medium to possess "no great advantages over the standard medium". Wilson's recommendation of the substitution of yeast-extract for beef-extract has been officially recognized in England but Bowers and Hucker (3) found such a substitution to result in fewer, though larger, colonies. The work of Shrader (16) provides a starting point for much needed research on the influence of the specific substances in the different ingredients of plate count media as they relate to nitrogen metabolism,

oxidation-reduction potentials, etc. Under the general direction of Dr. R. S. Breed, Chairman of the American Public Health Association's Committee on Standard Methods for the Bacteriological Examination of Milk and Dairy Products, very extensive comparisons have been made of the proposed Bowers and Hucker medium and other media. In summarizing this work Yale (27) notes that some have used media which may prove more desirable even than the tryptone-glucose-skim milk medium of Bowers and Hucker.

The studies of the Geneva group (12) have focused attention on the disconcertingly wide variations of temperature in some types of incubators in common use, particularly those of the anhydric type. Special consideration is being given to this serious problem by the above-mentioned committee of the American Public Health Association with the expectation of finding feasible methods for converting unsatisfactory incubators into satisfactory equipment.

Following the recommendation of Perderson and Yale (13) a large number of studies prove that the 32°C. count is frequently larger and less variable than the 37°C. count, the incubation period being two days in each case. Wilson believes that "the selection of a temperature of 32°C. has little to be said for it", arguing that another incubator would be necessary in some laboratories and that 37°C. favours parasitic bacteria and is the temperature used in the reduction test. A possible necessity of purchasing extra equipment is a drawback but as Wilson observes, "If it could be shown that 32°C. was the real temperature of preference the laboratories ought to equip themselves with a fresh incubator or else stop doing plate counts on milk altogether". Since the plate count is not used for the identification or special enumeration of the pathogens it is not at all clear why the assumed favouring of parasitic bacteria is advantageous. There seems also to be no point in an artificially-produced correlation between the plate count and the reduction test. Wilson's objection that the incubation temperature is an arbitrary matter should be extended to include the incubation period. For two-day incubation 32°C. seems to be a significant temperature.

Yale (27) has summarized the very extensive American work on the proposed new techniques, finding that they increase counts an average of 59 per cent. in raw milk, 120 per cent. in grade A pasteurized milk, 191 per cent. in grade B pasteurized milk, and 245 per cent. in pasteurized cream. Further extensive comparisons are now in progress. The tendency of the modified methods to widen the gap between milks of high and low bacterial content would seem to minimize the extent of adjustment necessary in present grade standards based on plate counts.

Regarding the plate count as a measure of keeping quality Robertson and Frayer (15) proposed the logarithmic (geometric) mean, thus relating the count to the time factor and geometric progression in bacterial growth. It is not made clear why the milk-control official, who is presumably interested in the total number of bacteria in a sample of milk at an instant of time primarily as a measure of its past history, should limit his purpose and outlook to the prediction of keeping quality. The logarithmic mean is specified in the United

States Public Health Service Milk Ordinance and Code (24) in order to "snub" the influence of the occasional high count in the series of counts in an individual supply for grading purposes. It would appear that the necessity for and degree of such "snubbing" will vary in different circumstances and is in any case a strictly arbitrary matter. When the logarithmic average is used arbitration ceases. Bigger and Griffiths (2) consider the logarithmic mean to be mathematically unsound but recognize a possible useful practical application. They suggest a weighted mean determined by computations so complex that the probability of its universal adoption seems remote. Leete (10) prefers the three-out-of-four method which is the arithmetic average of the lowest 75 per cent. of the counts. While this method also may not be universally applicable, the principle it illustrates is well tried in other fields of milk control and has much to recommend it in this case.

Many studies have been made of the variability exhibited by replicate plate counts, most of which have been reviewed by Wilson. His own experimental data are by no means extreme and he suggests the following, with certain reservations, "as a suitable allowance for counts based on different numbers of plates":

Count made on 1 plate: allow ± 90 per cent. of the count.
Count made on 2 plates: allow ± 64 per cent. of the mean count.
Count made on 3 plates: allow ± 52 per cent. of the mean count.
Count made on 4 plates: allow ± 45 per cent. of the mean count.
Count made on 5 plates: allow ± 40 per cent. of the mean count.

In absolute values this means that, "if the observed count on a single plate is 300,000 per ml., the real count probably lies between 300,000 ± 90 per cent., *i.e.*, between 30,000 and 570,000 per ml". That this view is moderate is shown by the results of Mattick *et al.* (11) who conclude that "it is clear that the practice of comparing results from one laboratory with those of another must be abandoned." Not a few students regard the uneven distribution of the bacteria in the milk as the principal cause of variability in the plate count.

The writer regards the plate count as a measure of the number of individual living bacteria in a sample of milk at a given instant of time irrespective of the later use of the measurement. For this purpose the count should constitute as high a proportion of the total number of bacteria in the milk as possible. Many of the proposed modifications tend to influence the plate count in the right direction and attempt to overcome one of the two outstanding weaknesses inherent in this method, viz., the inability of any one medium to support the growth of all types of bacteria found in milk. They have no apparent bearing on the other outstanding weakness of the plate count caused by the universally recognized tendency for bacteria to exist in clumps in milk. As milk supplies continue to improve bacteriologically and sharper distinctions in grading are demanded of a quantitative measure the problem of clumping must be faced or the usefulness of the plate count will diminish.

Not a little confusion has grown out of the introduction of statistical nomenclature into plate count considerations. The statistical expressions such as probable error, total error, etc., have to do with the fluctuation of replicate counts about a mean the representativeness of which, that is, its relation to the actual number of bacteria in the milk, is not necessarily measured. The reader should not be misled by the meaning attached by some authors to the words accuracy and reliability. It does not necessarily follow that a technique resulting in small variability measures the number of bacteria in milk more adequately than one giving more variable results. This is more aggravated in plate-count work than in many fields of biology using statistical analysis satisfactorily because of the clumping tendency of bacteria in milk and the inability of the plate count to measure the individuals in the clump.

THE DIRECT MICROSCOPIC (BREED) COUNT

Wilson has reviewed the literature on the Breed count from a statistical point of view and concludes that "for all practical purposes, actual counts are not worth making by the Breed method unless there is an average of at least one organism per field. Under these conditions, if reasonably accurate counts are desired, at least 100 fields should be examined." Strynadka and Thornton (18) found great variation between the 60, 1,000, 2,000 and 6,000 field counts of aseptically-drawn milk. They believe that 0.01 cc. may not constitute a representative sample for the precise estimation of bacterial numbers in this class of milk and recommend the routine reporting of the number of microscopic fields on which Breed counts are based. Robertson *et al.* (15) do not consider the Breed count as accurate as the plate count in milks of low bacterial content unless more microscopic fields are observed than is practical. Whitehead (25) found that certain Gram-negative bacilli growing in milk or introduced into milk from solid media may lose their staining properties, recognizing therein a possible element of error in the Breed count. The evidence appears to be, therefore, that as the bacterial content of milk decreases the usefulness of the Breed count also decreases although there is general recognition of the diagnostic value of a microscopic examination of the milk.

THE METHYLENE BLUE REDUCTION TEST

On the recommendation of Thornton and Sandin (22) the American Public Health Association has adopted as standard for the methylene blue reduction test a concentration of 1 part of methylene blue thiocyanate to 300,000 parts of milk. This dye was shown to lend itself to preparation in a state of purity not practically obtainable with the formerly used methylene blue chloride. Standard tablets of methylene blue thiocyanate are now on the market. Probably because of the ionization of either salt in aqueous solution with the formation of the same cation, the two salts give similar results as oxidation-reduction indicators in milk. Conn (6) reports wide variations in the concentration of the dye used at different times both in Europe and on this continent, the American tablets having been

more uniformly standardized than the Danish tablets. Thornton and Sandin found an average difference of 30 minutes in reduction times due to the new increased concentration, while Johns (9) reports a difference of 20 per cent. Frayer's results (8), on the other hand, are in such variance with this that it is difficult at present to find an explanation other than that he used a different end-point of reduction. Very favourable reports have appeared in support of the substitution of resazurin for methylene blue in the reduction test, the end-point to be read after incubation for one hour (14). Since the colour changes of this dye have not as yet been adequately related to present universally accepted theories of dye reduction in milk, the resazurin test must still be considered as being in an experimental stage. Wilson (26) and Thornton *et al.* (23) consider that the reduction test is less influenced by the clumping of bacteria than is the plate count.

On the recommendation of Wilson the modified reduction test has received official recognition in England. The main modification is the agitation of the tubes of milk during incubation for the purpose of keeping the butterfat and entangled bacteria more evenly distributed in the milk. This technique was first suggested by Skar (17) and developed by Thornton and Hastings (21). Thornton (20) does not consider that the accuracy of either test has been established, except as variability in replicates may be related to accuracy, and recommends the continuance of the present method as standard. Johns (9) is in disagreement with this view, presenting further data relating to variability.

It has usually been considered that leucocytes are a factor in the reduction test but workers in this laboratory (19) believe that they are rarely, if ever, a main or significant influence on reduction times in practice. End-point difficulties in both the standard and modified tests and the influence of incubation in the dark are among the problems requiring further research consideration before more satisfactory standards of technique can be introduced.

Many investigators, including your reviewer, have claimed empirically that the reduction test is a measure of bacterial activity in or keeping quality of milk, the unexpressed inference being that it is less well suited as a measure of bacterial numbers. Actually the reduction of methylene blue is related in a fairly well recognized manner to the oxidation-reduction potential changes undergone by the milk. The evidence is not imposing that the reduction test correlates more closely with that ill-defined something called keeping quality than with bacterial numbers. The writer approaches the problems of the reduction test in its relation to bacterial numbers without any necessary implication of the idea of keeping quality. Irrespective of the soundness of this view it is apparent that some of the conflicting results reported in the literature would disappear were there unanimity of opinion on this point.

COMPARATIVE ACCURACIES

There is evidence of considerable existing confusion not only as to what these tests can be expected to measure but even as to the purpose of applying

quantitative tests in milk control (4). The writer suggests that the milk-control official is interested in such tests because they distinguish milks of high and low bacterial content and that milk of low bacterial content is desirable from a public health point of view perhaps because carefully produced milk is less likely to contain pathogenic bacteria but certainly because it will have undergone less chemical change and it appeals to an aesthetic sense rapidly becoming conscious of bacterial contamination of food. There are reasons for regarding the actual total number of bacteria in milk as its best historian. For predicting keeping quality the value of total numbers has been questioned on unimposing evidence.

If a useful purpose is to be served by comparing the accuracies of the plate count and the reduction test (the Breed count appears to have distinct limitations as a quantitative measure) or if the tests are to be substituted interchangeably, it is necessary to regard them as measures of the same thing or at least that their results may be expressed in common terms. They are so regarded in the following comments.

The modified reduction test has been officially adopted in England in the place of the plate count for the bacteriological grading of raw milk on the recommendation of Wilson, who believes the reduction test to be more accurate. In his condemnation of the plate count, Wilson, though stressing the great variability of replicates, does not limit his argument to this weakness deeming clumping and other factors of importance. On this continent the reduction test does not enjoy such popularity. Using variability and a keeping quality test as criteria, Robertson *et al.* favour the plate count. Many others have compared these tests using somewhat similar criteria and come to conflicting conclusions. However, the extent of variability about a mean, the true value of which is unknown, cannot be an adequate measure of accuracy in the plate count because of the clumping of the bacteria in the milk. It is probably inadequate when applied to the reduction test because, among other things, of the varying rates of oxygen consumption by different bacteria. Comparison with another test of unknown accuracy also appears to be futile for this purpose. Thornton *et al.* (23) used a different approach and concluded that production methods designed to keep bacteria out of milk were more clearly reflected in reduction times than in plate counts. Ellinger (7) has found the reduction test more useful than the plate count in an extensive milk-improvement program. It is difficult to escape the conviction that unjustifiable conclusions are frequently being drawn from plate counts in both practice and research and that the reduction test is growing in favour as a general measure of bacterial numbers in raw milk.

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THE NUTRITIONAL ASPECTS OF MILK PASTEURIZATION*

THERE is no convincing evidence that raw milk, even if it were safe, is superior to pasteurized milk in infant feeding. Pasteurized milk is probably better because it is more easily digested. The idea of splitting hairs over slight assumed differences is absurd. We have an immense amount of clinical evidence gathered from many countries which shows that pasteurized milk has fulfilled the needs for feeding infants and children over many years, with no evidence of damage, provided the loss of vitamin C is made good. The opponents of pasteurized milk have conspicuously failed to make a case against it in favour of the raw product.

The experience of numerous investigators, including the present writer, and covering many years of studies with animals, shows that pasteurized milk, milk powders and evaporated milks are essentially the equivalents of raw milk in nutrition. The differences between them is not sufficient to warrant serious consideration.

It seems strange indeed that when we accept so generally the cooking of most of our foods, there should still remain in certain areas a serious objection to the mild heat treatment of milk, involved in pasteurization. The menace of bovine tuberculosis to the health of children is so great that universal pasteurization would be imperative if only for the prevention of the spread of this disease alone among children.

E. V. McCollum, Professor of Biochemistry, Johns Hopkins School of Hygiene and Public Health.* Am. J. Pub. Health, 1934, **24: 956.

Controlling Contamination of Raw Milk

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ONE of the objects in the public health control of milk supplies is to encourage milk consumption. The sanitary conditions under which the milk is produced should not only result in a minimum bacterial contamination of the milk but should also appeal to the consumer were he to visit the dairy farm at milking time. Milk of insanitary quality or of high bacterial content, even when pasteurized, may produce intestinal disturbances in infants. Pasteurization cannot be regarded as a substitute for sanitary milk production methods.

Of the several routine tests applied to milk, it is probable that the sediment test has been overstressed. The test appeals to the dairyman because the result is visible to the eye, but the test does not reveal dissolved dirt nor does it give information as to the presence of dirt in the milk prior to straining or filtering at the farm. The introduction of the sediment test has often brought rapid improvement but investigation has shown that in many cases the dairyman had made no improvement whatever in the cleaning of cows' udders, barn floors, hands of the milker, or milking stools, but had merely begun to filter the milk more effectively. The sediment test was then of little value. However, such testing afforded an opportunity for instructing the farmer how best to keep dirt out of the milk and it is gratifying that inspectors now find that the straining of milk on many of the farms is almost superfluous. Everywhere there has been emphasis placed by inspectors on the need for strict cleanliness so that contamination may be reduced to a minimum. Farmers have been instructed regarding the necessity of proper sterilization of utensils and the elimination of the old-fashioned strainer cloths. The latter have been replaced by sterilized cotton pads which are discarded after use.

In the earlier stages farm inspection disclosed that in many cases the utensils neither looked nor felt clean and, therefore, could not be easily disinfected. As the milk sanitation program progressed, chemical sterilization came into more general use but in our experience there was a lack of uniformity amongst the producers in the efficiency of sterilization of utensils (1). Bacteriological surveys showed that non-sterile utensils were the main cause of sub-standard milk as determined by the reduction test. Farm inspection disclosed the fact that in many cases insufficient chlorine solution was being used which resulted in parts of the inside surfaces not being touched while other parts were not exposed to the chemical for a sufficient length of time. Effectual methods of applying the disinfectant solutions immediately before milking, thus preventing further bac-

terial growth before use, have been instrumental in minimizing the quantity of sub-standard milk produced. Cooling of milk has been greatly improved. Surface milk coolers are now rarely used where inspection is conducted. In their place, cans of milk are immersed in fresh cold water or chilled by ice. The initial temperature of the water from wells seldom exceeds 45°F. and with the intelligent co-operation of the dairymen satisfactory cooling is being obtained on many farms where previously high bacterial counts were regularly reported. The purchase and use of suitable thermometers have brought about marked improvement.

To record what can be accomplished by a municipality in improving the quality of its raw milk supply through satisfactory inspection and laboratory services, an outline of the progress in the city of Edmonton during the past seventeen years is presented.

Since 1920, when the writer was first associated with the Board of Health, a continuous program of improvement of the raw milk supplies of Edmonton has been conducted. From 1921 to 1929 control was exercised through a milk ordinance of the "thou shalt, thou shalt not" type. The plate count was used as the measure of the bacterial content of the milk. From 1930 to 1932 the same ordinance was enforced but the methylene blue reduction test was used in the place of the plate count. Since 1932 a revised milk ordinance has been followed, based largely on the Standard Milk Ordinance of the United States Public Health Service (2). The methylene blue reduction test has continued to be used. Facilities for the laboratory control have been provided in the Provincial Laboratory, University of Alberta, where plate counts have been made. The methylene blue reduction tests have been conducted either in the laboratory of the Local Board of Health or under its direct supervision.

Prior to 1929, improvement in the milk supply was so slow as to be discouraging. In this period plate counts were used as the basis for control. It was found that high plate counts were almost invariably the result of lack of proper cooling of the milk at the farm. When an adequate cooling system was installed and properly used, the plate count fell promptly. Unfortunately, the reduction occasioned by adequate cooling overshadowed the lesser reduction following the application of proper utensil disinfection. It was found difficult, therefore, to introduce adequate methods for utensil disinfection because the results so frequently were not reflected in lower plate counts.

The gradual improvement in Edmonton milk as measured by the plate count is shown in table I. The high cost of making plate counts limited seriously the extent of this method. As the figures include both pasteurized and raw milk in varying proportions, the result is not as clearly shown as would be the case if the data related to raw milk alone.

During the years 1926-1929, a large pasteurizing plant in the city applied the methylene blue reduction test to its raw milk, and as a result of their experience the reduction test became in 1930 an essential part of the milk-control program of the Board of Health.

Following the adoption of the reduction test, four classes of raw millk, based on the classification presented in "Standard Methods of Milk Analysis"

(3), were recognized. The results are presented in table II. It will be noted from this table that classes 3 and 4 were no longer recognized in 1932. Class 1 milk became the only acceptable milk for distribution, the rejected milk being used in the making of butter.

TABLE I

CLASSIFICATION OF PLATE COUNTS OF EDMONTON MILKS IN PERCENTAGE
(Taken from Annual Reports of the Local Board of Health)

Year	No. Samples	Under 15,000	15,000 to 40,000	Under 50,000	Under 100,000	100,000 to 400,000	100,000 to 500,000	Over 400,000	Over 500,000	Over 1,000,000
1921	401	..	..	..	60.0	..	..	..	..	..
1922	557	..	..	..	63.0	..	22.4	..	13.6	7.4
1923	538	..	..	..	70.5	..	17.4	..	12.1	6.8
1924	602	..	..	..	65.0	..	22.1	..	12.9	7.3
1925	876	..	..	..	48.9	..	29.0	..	22.1	11.1
1926	827	..	..	57.1	72.8	..	18.7	..	8.5	4.9
1927	786	..	..	63.0	78.0	..	17.9	..	4.1	1.8
1928	882	..	..	64.0	79.6	..	16.7	..	2.2	1.2
1929	805	..	..	59.5	75.3	..	19.4	..	5.4	1.9
1930	1024	..	..	87.6	94.0	..	5.4	..	0.6	0.3
1931	1162	73.0	14.8	..	95.5	3.5	..	1.0	..	..
1932	1232	79.3	10.4	..	95.1	2.2	..	2.5	..	..
1933	1293	76.4	12.9	..	94.3	3.4	..	1.2	..	..
1934	1533	75.5	13.7	..	96.6	3.1	..	0.3	..	..
1935	1470	75.5	14.7	..	96.8	2.1	..	1.1	..	..
1936	1291	75.3	14.9	..	97.0	2.2	..	0.8	..	..

TABLE II

THE REDUCTION TEST CLASSIFICATION IN PERCENTAGE OF ALL MILK SHIPMENTS ARRIVING AT THE PASTEURIZING PLANTS DURING JULY, 1930 AND JULY, 1932

Year	Class	WEEK				Average
		First	Second	Third	Fourth	
1930	1	36	50	34	47	41.75
	2	47	38	48	46	44.75
	3	12	10	15	6	10.75
	4	5	2	3	1	2.75
1932	1	96.83	98.28	96.56	97.19	97.21
	2	3.17	1.72	3.44	2.81	2.79

From the public health viewpoint, the bacterial content must be considered as one of the essential qualities of milk. It must, however, be recognized that it is only one of the qualities. In our experience, the stress laid on the bacterial content of market milk made it difficult to persuade many producers to effect those improvements which are not directly reflected in bacteriological tests. Recognizing the importance of the regulations relating to the production of clean milk and its safeguarding by pasteurization, the Board of Health gave careful consideration to the Standard Milk Ordinance of the United States Public Health Service. As a result of the study, the Board adopted the major regulations of the Standard Milk Ordinance.

The enforcement of the ordinance was preceded in 1931 by an educational program that had as its basis the recognition of the producer's merit. In 1932 all farm inspections were made from the point of view of the proposed new

ordinance. During that year only 54 per cent. of the producers shipping milk to pasteurizing plants complied with all the proposed regulations that related to the production of the highest possible grade of milk intended for pasteurization. In fact, the requirements were the same, apart from not requiring medical examination of farm personnel, as would relate to the sale of Grade "A" raw milk. It was planned that the ordinance would have the effect of law during the summer of 1935 and the producers were so warned. Between 1932 and 1935 there was little change in the number of those complying with all the regulations but in 1936, 95 per cent. of the producers were in a position to supply the highest possible grade of milk intended for pasteurization. Through circumstances outside the control of this Board, the ordinance has not yet become law. Striking improvement, however, has been obtained and there can be no doubt that the application of the principles of the Standard Milk Ordinance has brought about a standard unattainable by any system previously tried.

THE METHYLENE BLUE REDUCTION TEST

As previously mentioned, the methylene blue reduction test was introduced as a routine procedure in 1930, and raw milk was classified on the basis of the findings of this test. Since 1932 only class 1 milk has been permitted to be pasteurized and distributed.

In our present practice, a test is made at least once a week of a sample of each producer's milk. For class 1 milk the reduction time must not be less than 5½ hours. If on two occasions in any three-months' period samples are found that reduce methylene blue in less than 5½ hours, the producer is notified and his licence is temporarily suspended. If examination in three days' time still shows the milk to be below class 1, the supply is excluded until the next regular testing. Depending on the findings of this test, the producer's licence is either reinstated or revoked. The producer receives a warning if the test indicates that the reduction time is approaching the minimum period of 5½ hours, since experience has shown that it is likely that the milk will fall below class 1 on the succeeding regular testing. This information is appreciated by the producers.

The improvement in the bacterial content of the milk during the period 1930-1936, in which the methylene blue reduction test has been used, is presented in table III. In 1930, 74 per cent. of the shipments met the requirements of class 1 milk and in 1936, 97.6 per cent. Striking improvement followed the introduction of the methylene blue reduction test and the interpretation of the findings to the producers.

The application of the methylene blue reduction test was not without difficulty. Almost immediately after its introduction a proportion of producers, some of whom had previously been looked upon as good dairymen, shipped lower class milk frequently. The cooling of the milk was satisfactory and the cause was not apparent. Samples were received in which reduction of methylene blue occurred in periods of less than an hour and in which the plate count was low. Such findings are presented in table IV, together with instances in which the high plate count was in conformity with the reduction test findings.

As a result of the occasional conflict of findings between the plate counts

and the reduction test, the test fell into disfavour with producers. Before discrediting the test, bacteriological studies were conducted, through the cooperation of the Department of Dairying of the University of Alberta, of the producer's methods on farms on which difficulty was found in maintaining the

TABLE III

THE PERCENTAGE OF THE TOTAL MILK SHIPMENTS RECEIVED AT THE PASTEURIZING PLANTS WHICH DID NOT REDUCE METHYLENE BLUE IN 5½ HOURS, AS REVEALED BY THE WEEKLY TESTS

(Taken from the annual report of the Local Board of Health, 1936)

	1930	1931	1932	1933	1934	1935	1936
January	..	90.82	95.11	96.68	97.62	97.95	99.06
February	72.	90.55	95.10	97.84	96.97	98.38	99.76
March	75.5	91.51	95.67	97.08	98.38	98.92	99.41
April	77.5	87.21	96.75	96.76	96.97	98.27	98.60
May	65.	87.01	91.13	95.24	93.73	95.82	94.55
June	65.5	79.88	85.20	93.22	93.29	94.76	94.32
July	42.	77.20	97.21	92.64	92.64	95.27	94.32
August	64.	83.92	91.54	92.86	94.65	95.78	97.40
September	88.	92.18	95.38	97.73	98.16	98.71	97.77
October	91.5	97.19	97.95	98.38	99.14	98.46	98.28
November	88.	97.19	96.35	96.51	99.35	98.81	98.10
December	88.	91.33	97.	99.57	97.95	98.92	99.07
Average	74.2	88.84	94.53	96.04	96.57	97.50	97.55
No. of tests		11,960	12,600	12,422	12,401	10,806	11,458

TABLE IV

PLATE COUNTS AND REDUCTION TIMES OF SOME SAMPLES OF MILK FROM A NUMBER OF PRODUCERS

Producer	Sample	Plate Count	Reduction Time
M	1	53,000	1 hour 50 minutes
	2	51,000	4 " 30 "
K	1	10,000	5 " 30 "
	2	11,000	5 " 00 "
	3	55,000	5 " 00 "
	4	19,000	1 " 45 "
W	1	4,000	5 " 00 "
	2	10,000	0 " 35 "
	3	58,000	0 " 45 "
D	1	over 300,000	0 " 50 "
	2	6,000	0 " 35 "
	3	10,000	0 " 35 "
	4	170,000	0 " 35 "
B	1	8,000	5 " 30 "
S	1	3,000	Less than 5 hours

standards. The findings (1) revealed that when the plate count was low and the reduction time less than 5½ hours, non-sterile utensils were usually the source of the contamination. Since these studies, it has been possible to trace with comparative ease the source of the contamination on any farm on which substandard milk is frequently reported.

It is interesting that similar difficulties have recently been reported in England (4). The experience in Edmonton, covering a period of seventeen years with the plate count method and ten years with the reduction test, appears to indicate that the use of the plate count tends to stress the effect of improper cooling of milk, while utensil contamination is not adequately measured. The reduction test seems to go further and measures utensil contamination more adequately.

In reviewing the results obtained, the fact that over 95 per cent. of the milk shipments coming to the city in 1936 did not reduce methylene blue in 5½ hours indicates that the producers are co-operating satisfactorily with the Board of Health. However, the majority of producers are unable to maintain the standard continuously. In 1930, only 2 per cent. of the producers attained a record of not shipping any substandard milk. In 1932 the percentage was 20; in 1934, 25; and in 1936, 33 per cent. achieved this record.

As previously stated, the studies made by Professor Thornton and his colleagues (1) showed that the failure to maintain continuously the standard was due to the lack of adequate methods for the sterilization of utensils; and, further, that any practical method of utensil disinfection which permits the continuous shipping of milk that will not reduce methylene blue in less than 5½ hours, results automatically in the production of milk which will not reduce methylene blue in a much longer period than 5½ hours. It is apparent, therefore, that if the standard of milk is to be raised in Edmonton, further attention must be given to the problem of adequate methods of utensil disinfection.

SUMMARY

After seventeen years of continuous effort to improve the raw milk supply of Edmonton, there is justification for the belief that the use of the methylene blue reduction test, because it measures utensil contamination more effectively, permits the attainment of higher standards than does the plate count; and that the adoption of the principles of the Standard Milk Ordinance (United States Public Health Service) brings many desirable results more quickly than possible under the old type of ordinance.

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The Coliform Test in Pasteurized Milk

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IN the Division of Laboratories, Department of Public Health, Toronto, about 15,000 pasteurized milk samples are received annually for routine testing.

The standard-agar plate count is employed, using 1:100 and 1:1,000 dilutions of each sample. The range of counts is between 5,000 and 100,000 per cc. The great majority of our counts are about 10,000 per cc. When the count exceeds 100,000, an advisory letter is sent from the Food Control Division to the dairy concerned. Possibly a count of 100,000 per cc. is unduly lenient but it is felt that a count of 1,000 per cc., as recommended by Barnes (1), is somewhat severe.

A study of the presence of coliform-group organisms was suggested because a number of the larger dairies were finding it useful as a routine test in controlling production and because it was included in the sixth edition of "Standard Methods for the Examination of Milk and Dairy Products".

At the outset, we considered testing our bottled specimens in 10-cc. quantities as advocated by Savage (2) and Wilson (3), but were somewhat surprised to find that a significant percentage of samples yielded a positive presumptive test with standard brilliant-green lactose-bile media, using 1 cc. amounts only. About 2,200 specimens, therefore, were taken at random, and, tested in this amount, yielded 58 per cent. positive presumptive tests.

Such a finding called for further investigation, particularly since McCrady and Langevin (4) had shown that coliform bacilli should not be present in more than 10-20 per cent. of samples of pasteurized milk. Since the original group of 2,200 specimens represented such varied products as milk, chocolate dairy drink, cereal milk, cream, ice cream, and sour cream, further observations were made using 857 specimens restricted to milk and cream. In this series, 46 per cent. of positive presumptive tests was obtained.

This latter group of samples was drawn from 53 dairies, and it appeared worth while determining whether any of the plants so contributing could attain the standard previously accepted.

Table I presents results obtained with seven of the larger dairies operating in the city and contributing 442 out of the 857 specimens which yielded an average of 46 per cent. positive presumptive tests. The table possesses the rather common defect of basing percentages on less than 100 samples but, nevertheless, provides some interesting data.

In the first place, it would seem that a considerable betterment of the 46 per cent. group average is not unattainable in individual cases and that, therefore, this standard is not unduly severe. In the second place, it is apparent that, while internal laboratory control or expert veterinary supervision is helpful, it is not in itself a determining factor in obtaining a lower than average percentage. To pursue this point further would entail profitless divagation into individual plant situations, but our conclusions based on knowledge of those conditions, lead us to believe that, given an adequate but not necessarily elaborate equipment, the conscientious effort of a trained personnel is the essential requisite.

TABLE I

SEVEN DAIRIES CONTRIBUTING 442 OUT OF GROUP OF 857 TOTAL SPECIMENS

Dairy	No. of Specimens	Type of Control	% Positive Presumptive
A	111	Lab.	30
B	65	Lab.	66
C	56	None	27
D	66	Supervised	60
E	47	None	45
F	30	None	34
G	67	Lab.	20
All Dairies (53)	857	Varied	46

The next question which naturally arises is whether the standard brilliant-green lactose-bile medium is in practical use, specific for the coli-aerogenes group. "Standard Methods for the Examination of Milk and Dairy Products" wisely recommends that, for routine work, the test for the coliform group be limited to the presumptive test. However, with a still high average of 46 per cent. positive findings in our group, it was considered worth while attempting to carry this test further toward completion.

Accordingly, 402 positive presumptive tests obtained in the series of 857 specimens tested, were brought through to the "completed test" as required by "Standard Methods of Water Analyses", 8th edition. The results are shown in table II. It should be noted that this table includes not only the contributions of positive presumptive tests made by the seven large dairies represented in table I, but also those of the remaining 46 dairies in the Toronto area.

In a general way, inspection of table II shows a reduction from 46 per cent. of samples showing the positive presumptive test to 29 per cent. of the original series of 857 specimens, which survived to yield a "completed test". At each step, there is a considerable reduction. In proceeding, for instance, from the "presumptive" to the "confirmed" test, there is a 9 per cent. loss. As previously pointed out by McCrady (5) and others, this loss is due to the fact that the "confirmed" test possesses the inherent weakness of being dependent on the experience of the individual worker. In the attempt to select "typical"

B. coli colonies from eosin-methylene blue plates, many colonies of the aerogenes group may be overlooked.

Typical colonies so obtained were sub-cultured to agar slants and tested for gas production and appearance upon Gram's stain. At this point, we rejected for the gas-production test all sub-cultures which showed the presence of any organism other than Gram-negative, non-spore bacilli, but it is noteworthy that, even allowing for error in original selection and subsequent handling of these "typical" colonies fished from the eosin-methylene blue plates, the surviving organisms in brilliant-green broth were predominantly Gram-negative non-spore bacilli which succeeded in producing gas upon re-inoculation to lactose broth.

TABLE II

GROUP OF 857 TOTAL SPECIMENS CARRIED TO COMPLETED TEST

No. Tested	Test Made	No. Eliminated	No. Positive	% Positive of Total
857	Presumptive	455	402	46
402	Confirmed	84	318	37
318	Completed	65*	253	29

*Of this number, 50 eliminated by Gram's stain and 15 failed to produce gas.

Having obtained a positive "completed" test in 29 per cent. of the group of 857 specimens, we were led to consider whether a further differentiation between the aerogenes and colon group proper might be of value. We had in mind the statement of Wilson (6) that such differentiation might serve to distinguish between unsatisfactory processing and recontamination, and this appeared to us a matter of some practical significance.

Accordingly, 183 cultures from among the 253 total cultures which, in table II, yielded a positive completed test, were studied for the purpose of differentiation (table III).

In this connection, the reaction classification for the coli-aerogenes group given in "Standard Methods of Water Analyses", 8th edition (p. 270), appeared hopelessly complicated; so we employed the media indicated by the usual abbreviations in table III, which is based in the main upon Topley and Wilson's method of differentiation (7).

Bearing in mind the correlations both positive and negative required by the above classification, it is evident that a high percentage (53) of this series of 183 specimens must be allotted to the colon group proper.

We had expected to find a much greater percentage of specimens fall into the aerogenes-intermediate group if due to re-contamination of the pasteurized product, unless, of course, this re-contamination were attributable to direct handling by operatives, which appeared unlikely.

Another explanation for the occurrence of this high percentage of the colon group proper might lie in the possibility that we had been dealing with an inadequately pasteurized product in the first place, or that the surviving organisms all belonged to the heat-resistant strains of the coliform group, as suggested by the studies of Wilson (8). We do not think this explanation probable, as earlier in the investigation we had taken 100 samples at random from the group of 857 specimens and tested them with the Kay-Graham phosphatase test (10-minute period only). All of these specimens so tested indicated adequate pasteurization and were inoculated into brilliant-green bile media. The remaining

TABLE III

DIFFERENTIATION OF 183 POSITIVE COMPLETED TESTS

No. of Specimens	Type of Correlation Shown	% of Group
50	None	27
15	V.P. + M.R. − IND. − CIT. + (aerogenes)	8
20	V.P. − M.R. + IND. − CIT. + (intermediate)	10
98	V.P. − M.R. + IND. + CIT. − (colon)	53

V.P.—Voges-Proskauer test. M.R.—Methyl red test.
Ind.—Indole production. Cit.—Citrate medium.

portion of each specimen was subjected to laboratory pasteurization in 10-cc. amounts and inoculated into brilliant-green media. Of this group, 57 per cent. yielded a positive presumptive test on first culture but a negative result after repasteurizing.

Since the milk-cooling systems in modern dairies are now entirely enclosed, it seems likely that the finding of so high a percentage of members of the colon group in the final product indicates that at some time incompletely pasteurized milk passed from the pasteurizer into the cooling and bottling section of the plant. In this section, there is a greater possibility of escape from destruction, in spite of the use of sterilizing solutions and hot water in the daily cleaning. Experience of dairy laboratories supports this view, as it is a common occurrence to obtain positive presumptive tests in the early run-off followed by a series of negative tests.

It is noteworthy, also, that most dairies have installed, or are installing, sterilizing troughs in which all pipe connections used in post-pasteurization distribution are taken down and soaked overnight.

Dr. G. S. Wilson (9), in his report to the Medical Research Council on the bacteriological grading of milk, recommends that the coliform test should be

used in the examination of ordinary pasteurized milk immediately after processing, supplemented by the use of the plate count at 37° C. in the examination of grade A pasteurized milk. If this recommendation be adopted and the coliform test be conducted as a routine in conjunction with the standard plate count, the suggested standard of 10 to 20 per cent. positive presumptive tests (with seasonal adjustment), as suggested by McCrady and Langevin, is not too rigorous, particularly when the tests are made on bottled specimens received directly from the dairies.

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(9) *Ibid.*, p. 375.

THE AMERICAN MEDICAL ASSOCIATION AND PASTEURIZATION*

SINCE disease germs are readily destroyed by well established methods of pasteurization, all milk for direct human consumption or for use in ice-cream, cheese or other milk products should be pasteurized according to officially approved methods. After pasteurization the milk should be so stored and protected that it will not be contaminated. Liquid pasteurized milk should be retailed in sealed bottles.

The pasteurization of milk is a public health measure. The public should demand pasteurized milk for drinking and the use of pasteurized milk in milk products. The dairy trade should universally adopt pasteurization in the interest of public health.

There is no cogent evidence that pasteurized milk is significantly inferior nutritionally to raw milk.

**Annual Report, International Association of Dairy and Milk Inspectors, 1935, page 51.*

The Use of the Phosphatase Test in the Control of Pasteurization

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IN 1935, Kay and Graham introduced the revised phosphatase test as a means of checking efficiency in pasteurization. Until that time none of the methods devised for this purpose had proved to be reliable. Thus, considerable interest was aroused in the new test. It is significant that in the past three years this interest has not waned; rather has it increased, with the result that the test is being applied in America and other countries and given further application in England. This increased interest may be attributed partly to the fact that each year as the value of pasteurization is being more widely recognized it is natural that a test so directly concerned with the pasteurization process should become more important. But also the fact that the phosphatase test is standing up under trial and establishing itself as useful and practicable has served to keep attention focused on it.

The importance of any method which will aid in the control of pasteurization can hardly be over-emphasized, since allegedly but imperfectly pasteurized milk presents a false security which may be fraught with greater peril than is the situation when raw milk is used. At least in the case of the latter, if caution is not exercised, it is the individual's responsibility.

It is the purpose of this article to discuss the phosphatase test and give in review its present position with respect to its usefulness and value as an aid in the control of the pasteurization process.

As pointed out by Kay (1) (2), there occurs naturally in raw milk the enzyme phosphatase, which hydrolyses phosphoric esters of a certain type, and which is destroyed by heat at a temperature just above the thermal death point of *Mycobacterium tuberculosis* which is said to be the most heat-resistant of all the known pathogenic organisms found in milk. Since the purpose of pasteurization is to destroy all pathogenic organisms in milk, the relationship of phosphatase in this connection becomes obvious. That the method for the estimation of phosphatase activity is extremely sensitive, adds no little to its value as a basis for a test. In this connection it should be noted that there are in fact two tests, a short one and a longer and more accurate one. These are known as Tests A and B, respectively. The technique for each is essentially the same, *i.e.*, a measurement of the amount of hydrolysis effected on the ester used as substrate by phosphatase in the milk being tested. Since the amount of this enzyme remaining in pasteurized milk is dependent on the degree of heat to which the milk has been subjected, an assay of the phosphatase activity gives a fairly direct determination of the extent to which the milk has been heated. The test owes a good deal of

its success to the fact that the ester di-sodium phenyl phosphate can be used as substrate, since not only is it rapidly hydrolysed by phosphatase at a suitable temperature but the phenol liberated during the hydrolysis lends itself to exact measurement by Folin and Ciocalteu's colorimetric phenol reagent.

Test A is designed for a first approximation, and is only roughly quantitative. It can be carried through to completion in half an hour, as the milk-buffer substrate mixture is incubated for only ten minutes at 47°C. It may be used as a field test and will pick out major faults readily. In this laboratory it was found that the addition of less than 5 per cent. raw milk to pasteurized milk could not be detected by test A; that 5 per cent. raw milk showed up a shade more blue in the treated tubes than in the control, but was under 2.3 Lovibond units of blue; and that 10 per cent. raw milk was well over 2.3 units. It is clear that with this test, any milk which shows more blue than the standard is at fault, but minor errors may go undetected. Therefore the more accurate test B should be applied to any milk in which the incubated tube (test A) does not exactly match the control or which for any other reason is under suspicion. With test B the incubation period is 24 hours at 37°C. These conditions of testing should be used only for milk pasteurized at 145°F. It is well known that the regulations respecting pasteurization vary slightly as to time and temperature in different places. Those responsible for recommending a suitable temperature for pasteurization try to make it such that there is a margin of safety with regard to freedom from pathogenic organisms, but often the margin is very narrow because the authorities have taken cognizance of the impairment by heat of the "cream-line" in milk, a factor so important in the marketing of this product. In order to adapt test B to variations in temperature of pasteurization, Kay and Graham (1) have drawn up a graph based on the results of some three hundred determinations. These results were obtained by pasteurizing samples of milk at various temperatures (between 137.5° and 150°F.) for 30 minutes and incubating at 37°C. with the phosphoric ester under test B conditions, for intervals of time ranging from 30 minutes to 24 hours. The points on the graph represent the minimum time of incubation for the testing of milk samples pasteurized properly at the various temperatures without the production of more than the standard colour of 2.3 blue units. The more accurate test B then, may be modified by changing the incubation period so that the test is suitable to different temperatures of pasteurization. For example, in Ontario the stipulated temperature for pasteurization is 143°F. From an examination of the Kay and Graham chart, the time of incubation of test B for milk properly pasteurized at this temperature is approximately four and a quarter hours. This incubation was found to be satisfactory when a survey of Ontario milk was made in 1937 (3), but it was felt that further work should be done on this time interval for test B, with accurately pasteurized Ontario milk, before the four-and-a-quarter hour period could be recommended. Through personal communication with Dr. A. L. MacNabb and his associates at the Department of Health of Ontario, it was learned that a very thorough trial is being given test B with a four-hour incubation period applied to milk pasteurized at 143°F. for 30 minutes under carefully

controlled conditions in the laboratory. They have found that milk pasteurized one degree below the required 143°F. can be readily picked out by the readings from the tintometer. This work will be published shortly.

Kay and Graham give the order of accuracy for test B to be such that it will indicate errors in pasteurization as follows: (a) 1½°F. below the minimum temperature for pasteurization; (b) heating (at 145°F.) for 20 instead of 30 minutes; (c) admixture of 0.25 per cent. raw milk with properly pasteurized. Anderson, Herschdörfer and Neave (4) made a careful examination of the technique of the phosphatase test and corroborated the findings of its originators. They conclude, however, that less than 0.25 per cent. raw milk may be detected by the test and in the discussion appended to their report Kay remarks that workers in Denmark claim the test will indicate 0.1 to 0.2 per cent. raw milk. Trembath and Newman (5) in Australia give the results of determinations on the efficiency of the test and these are in agreement with the conclusions of Kay. They also show that 0.2 per cent. raw milk may be detected. Storrs and Burgwald (6) of Ohio State University have checked the test and drawn conclusions similar to the Australian workers. Further confirmation of the accuracy of the test is given by Edwards and Nanji (7) of London, England. Gilcreas and Davis (8) at Albany, N.Y., introduced into the test a slight modification which will be discussed later, and found the modified test to be highly satisfactory for the control of pasteurization. They conclude that a shortening of the time of pasteurization by 5 minutes or more, or a lowering of the temperature by 1°F., or the addition of as little as 0.1 per cent. of raw milk, may be detected; and that adequately pasteurized milk improperly stored may give a positive test for phenol, due to the action of certain micro-organisms in the milk.

With respect to applying the test to pasteurization by the high-temperature short-time process, Kay and Graham present data which show that it may also be used satisfactorily for checking this type of pasteurization. Gilcreas and Davis found the test as they used it likewise satisfactory for this purpose. It is felt, however, that the application of the phosphatase test to "flash" pasteurization requires further investigation.

AMERICAN MODIFICATIONS OF THE TEST

Scharer (9) of the New York City Department of Health has modified the test of Kay and Graham considerably. The barbiturate buffer is replaced by a borate sodium hydroxide buffer, the phosphoric ester is purified to rid it of residual phenol and a more sensitive phenol detecting agent is used, *i.e.*, 2.6 dibromoquinonechloroimide. As a result it is possible to reduce the incubation time to 1 hour. The same precision and delicacy are claimed for this modified form of the test as for the original method of Kay and Graham. These modifications also lent themselves to the development of a field test which may be carried out in 20 minutes and which is said to detect a drop of 2°F. in temperature of pasteurization, a reduction of holding time of 10 minutes, or the addition of 1 per cent. raw milk. This short test has proved very valuable in New York City

which receives large volumes of milk pasteurized outside the city, since milk may be tested rapidly at the station before shipping and held back if the requirements of the test are not fulfilled.

Gilcreas and Davis (8) eliminated the use of the Lovibond tintometer in the test by developing a different method of measuring the blue colour produced by the phenol which is liberated by hydrolysis in the course of the test. The range of blue colour covered in the test was duplicated by the preparation of a series of inorganic solutions and thus a set of permanent standards was developed for determining by comparison the milligrams of phenol liberated by the phosphatase. The results are expressed in milligrams of phenol per 0.5 ml. of sample. For all the tests carried out by these investigators, test B with the 24-hour incubation period was used, though the milk was pasteurized at 143°F. This was possible because of the different standards which had been developed. The standard chosen for adequate pasteurization was a phenol value of 0.037 mg. per 0.5 ml. of sample examined. This figure is an average of results from 20 samples of milk properly pasteurized at 143°F. for 30 minutes. The maximum was 0.05 mg. and the minimum 0.03 mg. It would appear to be fairer to the operators of pasteurizing plants if the practice of Kay and Graham were followed and the maximum figure rather than the average chosen as the standard.

APPLICATION OF THE TEST IN GREAT BRITAIN AND OTHER COUNTRIES

In the papers of Kay and Graham (1) and Kay and Neave (10) reports are given of the application of tests A and B in England at the time the test was introduced. A high proportion of the samples of pasteurized milk tested was found to be inefficiently pasteurized. It was noted that where plants were properly designed and supervised, the product was satisfactory. In a more recent report of Hoy and Neave (11) further results are given on the checking of efficiency of pasteurization by the phosphatase test. As in the earlier studies, the samples tested came from London boroughs, from provincial towns, and some from rural districts. Four examples are given in detail of how the test presented the inspectors with a definite clue which led to the tracking down of defects in the pasteurizing plant which might otherwise have remained undiscovered. Perhaps the most interesting finding from this survey was that the results, when compared with the earlier ones, showed a decided improvement in the efficiency of the pasteurization plants where the various samples of milk had been processed.

The phosphatase test is being given a trial in many sections of the United States. From San Francisco comes the report of Geiger and Davis (12) on the application of the test to 155 samples of pasteurized milk and cream. (Test B was used with the incubation period modified to a one-hour period.) Of these samples, 16 per cent. were found to be inadequately pasteurized. The offending dairy plants were warned by the inspectors that any negligence in pasteurizing could be detected. The result of this warning was that all the subsequent samples taken from these plants passed the test. It was concluded that the test is one which may be relied upon to control proper pasteurization of milk and cream.

The State Department of Health at Albany, N.Y. (13), using the modification of Gilcreas and Davis, has examined 2,000 samples of pasteurized milk and cream. Of this number, 8 per cent. gave a result like raw milk and altogether 632 or about 29 per cent. of the samples were unsatisfactory. Investigation of these samples at fault usually revealed the trouble at the pasteurizing plant.

The Bureau of Dairy Products, Board of Health, Chicago (14), have used phosphatase test B with the incubation time for the enzyme-substrate mixture reduced from 24 hours to 8 hours as suggested by Kay and Graham (1) to correspond to the temperature of pasteurization which is 144°F. for Chicago. Thousands of samples of milk and cream were tested and it was concluded that 2.3 Lovibond blue units was a satisfactory standard for judging adequate pasteurization by the Chicago regulations. Through the application of the test it was discovered that pasteurizer charts were being tampered with, and as a result it was required that the recording thermometers in each plant be modified in such a way that should the chart be fraudulently moved it could easily be detected.

In the laboratories of the New York Department of Health (15), using the modifications of Scharer, 10,635 milk and cream samples were examined and of these 4.7 per cent. did not meet the requirements of the modified test. Of 1,081 samples of milk and cream from suspicious sources, 23.8 per cent. were inadequately pasteurized.

The Association of Official Agricultural Chemists in the United States is at present supervising a critical trial of the phosphatase test. Various laboratories throughout the country are co-operating in this work.

Through correspondence with Dr. D. J. MacKenzie of the Department of the Public Health, Nova Scotia, it has been learned that the test is being tried in his laboratory. The field test as devised by Scharer has been found useful within limits and the Gilcreas and Davis modification has proved satisfactory in practice. About 250 tests have been made.

Last June the results were presented (3) of the test applied to 218 samples of Ontario milk; 10.6 per cent. of the Toronto milk samples showed imperfect pasteurization and 13.9 per cent. of the samples from Ontario, exclusive of Toronto, were inadequately pasteurized.

It has already been mentioned that the Department of Health of Ontario is giving the test a thorough study in the laboratory. So far they have found in the case of any defective samples investigated, that the plant or plant operator has been at fault.

The Department of Public Health, City of Toronto, has also been using the test. In milk samples which gave positive results the fault was usually traced to the plant, even though the temperature recording chart was correct.

The workers at Melbourne, Australia (5), report that the test has been found successful when applied to milk, but when used on cream pasteurized by either the "holder" or "flash" methods it was not satisfactory. It is not clear from their paper whether the cream samples were diluted as recommended by Kay and Neave (16) before carrying out the test.

In many of the reports on the application of the phosphatase test, examples

are cited which show that the test may detect errors in the functioning of pasteurizing plants, whether deliberate or unintentional, which might not otherwise have been discovered. In this respect the test may be aptly described in the words of Kay as both "fool-proof" and "knave-proof". One should, however, keep in mind the rather unlikely possibility of some chemical being found which when added to the milk in traces will poison the enzyme without being harmful to the consumer.

USEFULNESS OF THE TEST FOR OTHER DAIRY PRODUCTS

Kay and Neave (16) give two methods of applying the test A to butter which, if the butter is not more than a few weeks old, will decide whether or not it has been made from raw or pasteurized cream. These investigators are also working on the application of the test to cheese.

Krueger (14) reports on the successful use of the test on curd milk, goat milk, vitamin D milk, and ice cream mix. His laboratory is also investigating the application to butter and cheeses of various types. The test was found to be unsatisfactory for chocolate milk or for ice cream to which certain colours and flavours had been added. Mr. McClure of the Ontario Department of Health, by personal communication, tells of similar experience with respect to chocolate milk. Vanilla flavouring, which is most popular in ice cream and which may be detected in some brands of chocolate milk, is due to the phenolic compound, vanillin, which, since it gives a positive reaction to Folin and Ciocalteu's reagent, would interfere with the reading of the results. Scharer's modification (9) is said to be suitable to chocolate milk. Dr. Scharer (personal correspondence) also says that the modified test has been applied to routine testing of butter and cheese with gratifying results.

PRECAUTIONS AND LIMITATIONS IN THE USE OF THE TEST

The directions for performing the test should be closely followed and all details accurately carried out. While it is a relatively simple test, nevertheless credence should be given results only when the test has been done by one experienced in the technique. All reagents used should be carefully prepared. In this laboratory (3) a series of anomalous results was obtained with one lot of buffer. The controls were apparently normal, but the incubated mixtures gave in some cases deep blue colour. When a new lot of buffer was used the results were again regular. The test should be performed on milk as soon after collection as possible. The milk may, however, be stored at a low temperature for some days without affecting its response to the test. Care should be taken to see that the test materials are not contaminated by phenolic soaps or other compounds which would affect the results.

There is considerable variation in the phosphatase content of the milk of individual cows. Thus the test when applied to milk from one or even a small number of cows may not meet the standards. Also an abnormal health condition which may be general with one herd may affect the phosphatase content of the milk. In relation to this, Storrs and Burgwald (6) are investigating the effects

of mastitis milk on the accuracy of the test. The Ontario Department of Health are also looking into this problem.

Finally it should be kept in mind that the test checks pasteurized milk only up to the completion of the pasteurization process, with the important exception that the addition of raw milk after that stage can be detected. In this connection Trembath and Newman (5) state that they found no definite correlation of the test with plate counts. This is not a surprising result. Moffat and MacKay (17) report that out of 100 milk samples which gave a negative reading for phosphatase, 44 gave a positive presumptive test for *B. coli*. After these samples were re-pasteurized in the laboratory the presumptive test was negative, which could indicate post-pasteurization infection.

It is almost redundant to point out that the test does not supersede plant inspection, but it does provide the inspector with a valuable tool by which his findings at the plant are checked in the laboratory. Furthermore, it may furnish him with evidence of leakage, mechanical faults, or inefficiency of the personnel connected with the operation of the plant, which might not have been disclosed before the introduction of the phosphatase test.

SUMMARY

The phosphatase test of Kay and Graham has been discussed with respect to the principle on which it is based, its accuracy, and adaptability for use on milk pasteurized at different temperatures. Some recent modifications are briefly dealt with. Reference is made to the application of the test in various countries and to its application to products other than milk. Some precautions in the performance of the test and limitations in its use are mentioned.

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The Nutritional Value of Raw and Pasteurized Milk

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FOR the adequate nutrition of human beings there must be supplied in the diet sufficient carbohydrate, fat and protein to satisfy the total energy requirement, inorganic elements and those vitamins which have been shown to be needed by humans. Studies of food consumption in the United States and in Canada have shown that the common dietary defects are: insufficient protein, insufficient calcium, and suboptimal supplies of the vitamins. Certain foods are particularly useful because they supply the frequently neglected constituents; these foods have been called protective. Of these, the most valuable is milk.

The average composition of cows' milk is as follows:

Water	87.7	per cent.
Fat	3.4	" "
Sugar	4.7	" "
Protein	3.4	" "
Ash	0.7	" "

One-sixth of the ash is calcium.

Milk is a solution of sugar, protein, mineral salts and vitamins with fat present in fine droplets as an emulsion. This physical nature of milk is important since it accounts for the ease of digestion; milk is the most digestible food. Milk fat, because of its low melting point and because it is emulsified, is more readily digested than other food fats.

Three proteins are present in milk: casein, lactalbumin, and lactoglobulin, the latter two in small amounts. Casein is the most valuable protein known to workers in nutrition since it supplies all the essential amino acids. It is particularly important because it makes good the deficiencies of grain proteins. Milk, contrary to common belief, is not an expensive source of protein. At current retail prices in Toronto one ounce of protein from milk costs ten cents and from round steak seven cents.

Milk is the most useful food source of calcium. In ordinary dietaries three-fourths of the calcium is supplied by milk. One pint of milk contains two-thirds of a gram of calcium, satisfying the daily need of an adult man for that element. If we take a glass of milk and two slices of whole-wheat bread, we secure 0.27 grams of calcium from the milk but only 0.02 grams from the bread.

Milk and the related product, butter, constitute the most important source of vitamin A and of flavin (a constituent of vitamin B_2) in American and

European dietaries. Milk contains significant amounts of vitamin B_1 but the content of vitamin C is small and variable. Milk should never be regarded as a source of this vitamin and, as clinical practice has abundantly proved, infants should receive a supply of vitamin C by the supplemental feeding of orange or tomato juice.

A recent survey by the Dominion Department of Agriculture (1) showed that in 3,213 families in various parts of the country 77 per cent. of the adults and 22 per cent. of the children did not drink milk. The state of nutrition in this country could be improved by an increase in the consumption of milk. Every scientific expert in nutrition would agree that a liberal use of milk improves health, provided that the milk is safe and does not spread infectious disease. Pasteurization offers the only known method for ensuring a safe supply of milk.

In 1934 there was reviewed in this JOURNAL (2) the existing information regarding the effects of pasteurization upon the nutritional value of milk. It was concluded that any changes produced by heating were insignificant. All the scientific work done since that time has substantiated that conclusion.

The most important study on raw and pasteurized milk in recent years has been that jointly carried on by the Rowett Institute and the National Institute for Research and Dairying, Reading, England. The first report (3) dealt with animal experiments to determine the changes in nutritional value produced by pasteurization. Commercial pasteurization was found not to interfere with the utilization of calcium and phosphorus from milk. It did not affect the digestibility nor the high biological value of the protein in milk. Vitamin A and carotene (the precursor of vitamin A) were not altered by pasteurization. During pasteurization there was a slight loss in vitamin B_1. It was found that about 20 per cent. of the vitamin C content of milk was destroyed by customary procedures but that this loss could be prevented by ensuring that the milk was not exposed to light prior to heating. The total nutritive value of raw and pasteurized milk was studied in growth experiments in young rats and no difference could be detected.

Krauss (4) has also studied the nutritive value of raw and heated milk in rats and has reported that he could find no difference, the two milks giving the same rate of growth. The lack of effect of pasteurization upon the vitamin A content of milk has also been demonstrated by Holmberg (5).

Since considerable scientific evidence was reviewed previously (2), extended references will not be made. Existing scientific knowledge on the effect of pasteurization can be summarized as follows:

1. The casein in milk is not altered in any way. Lactalbumin and lactoglobulin are coagulated, tending to make them more digestible. Accurate work has shown that the high nutritive value of milk protein is not lessened by pasteurization.
2. Sugar and fat in milk are not altered by pasteurization.

3. Calcium and phosphorus are as well absorbed from pasteurized as from raw milk.
4. Pasteurization does not diminish the vitamin A content of milk.
5. There is a small, insignificant loss of vitamin B_1.
6. The vitamin C content of milk is lessened by pasteurization but this can be prevented by keeping the milk from exposure to light. Since even raw milk must be supplemented with vitamin C for infant feeding, this effect of pasteurization has no practical importance.
7. Studies of the total nutritive value of milk have already shown that it is not altered by pasteurization.

In 1933 Savage (6) reviewed in the *Lancet* evidence regarding the effects of pasteurization. He summarized the review as follows:

"A study of the chemical changes and the composition of the two kinds of milk lends no support to the view that pasteurized milk is in any way inferior to raw milk for infant feeding.

"We are left therefore with the immense volume of clinical experience in this country, in U.S.A., and elsewhere, showing that pasteurized milk has satisfied the needs of infant and child feeding over very many years and without any evidence of detrimental loss, provided (as for milk generally) any possible deficiency of vitamin C is made good. With this mass of clinical experience available it is for the opponents to demonstrate nutritional harm by pasteurization and the experimental work cited shows that this they have conspicuously failed to do."

SUMMARY

Because of its high nutritive value milk is a food of primary importance. Consumption studies in Canada indicate that the use of milk should be increased, provided that it is rendered safe by pasteurization. This process does not lessen the nutritive value of milk; those constituents which are particularly useful in nutrition are not affected by heating.

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The Producer and Safe Milk

E. H. CLARKE

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THE producer who supplies milk for fluid consumption has certain responsibilities which may or may not be carried by those who supply milk for world markets. These responsibilities relate to the health of animals, sanitation, and the providing of an even supply and regular daily delivery of milk to the urban centres.

Nearly all milk supplied to the larger centres in Ontario, as in other Provinces, comes from herds supervised by the Health of Animals Division, Ottawa. Where the herd is under the Accredited plan or the Restricted Area plan, the producer is given financial compensation. The eradication of Bang's disease and mastitis must be undertaken by the producers themselves, and the recompense is in improved herds and improved quality of milk. The writer's experience is not uncommon. Some years ago several young pure-bred accredited cows were purchased, all subject to the blood test for Bang's disease. Six months after purchase one of these aborted. Under the supervision of Ottawa, blood samples were taken and of twenty-eight cattle, this particular cow was the only reactor. In six weeks there were six more reactors, and in a further six weeks as many more, with a loss of practically half the herd. Every precaution had been taken from the beginning. Similar stories could also be told by many producers regarding the ravishing of Bang's disease and also certain forms of mastitis. To secure safe animals to replace those eliminated by these diseases means the paying of high prices.

Pasteurization will make milk from diseased animals safe, but it will not make dirt-laden milk clean. Everyone supplying milk for liquid consumption must guard continuously every step in its production. The hay supply in the barn, dust in the stable, or the conditions of the pasture may create ropy milk. The herdsman must feed carefully for flavours, must feed regularly for supply, and must feed scientifically for quality of the milk and health of the animal. In milking and in the subsequent cooling, strict care must be taken. Everyone knows the simple daily rules to avoid insanitary milk. As soon as possible after the milk is drawn from the udder, it must be cooled to 40° F. or 50° F. This requires an abundant supply of extremely cold water, or ice, or mechanical refrigeration. If care is not taken at this point, the shipper finds the milk rejected and returned to him, involving financial loss and a possible reduction in quota accepted.

The majority of municipalities have sanitary standards for milk producers. It is regrettable that even yet some large municipalities pay no attention to the source of their milk supply. In practically every milk market the magazines and bulletins published by the producers' associations give instructions to

the dairy farmer in handling his milk. This educational progress has been going on for many years. The following is typical of the instructions sent out to reduce the bacteria:

Sources of Bacteria

Following are the usual sources of bacterial contamination:
1. Udder—Mastitis, or udder infection.
2. Stables—Dust and dirt particles from flanks of cows, from dust of air, etc.
3. Utensils—Insanitary or improperly cleaned pails, cans, milking machine tubes, coolers, strainers, etc.

Producing Low-Count Milk

1. Keep cows clean. Wash udders and teats, and wipe flanks with a damp cloth just previous to milking; clip hairs from udders and flanks regularly; avoid dust and strong-flavoured feed until after milking.
2. Eliminate milk of all infected udders (mastitis milk). It is also advisable to eliminate all milk from stripper cows late in lactation and also the foremilk from all cows.
3. Promptly cool evening's milk to 60° F. or less, and maintain this temperature at all times until milk is shipped. Cool morning's milk promptly unless it is delivered at once.
4. Clean utensils immediately after using.
   (a) Rinse in cold water.
   (b) Scrub with a stiff brush using hot alkali water.
   (c) Rinse and scald with boiling water.
   (d) Allow utensils to drain and dry promptly in a sanitary place.
5. Just previous to using, sterilize all milk utensils with a sterilizing solution.
6. Dry hand milking. It is also advisable to disinfect the hands and udder with a sterilizing solution just previous to milking. (Chlorine products are very satisfactory for sterilizing purposes.)

Only those who have shipped milk to urban centres realize the necessity of an even supply based on the requirements of the market. In larger cities, the summer sales are 20 to 25 per cent. below the winter sales. In other words, the peak supply and the low consumption come at the same period, with the inevitable cost increase to maintain the required supply. In the smaller towns, whose populations are increased by visitors, the summer consumption is much greater than the winter consumption.

In every controlled market the advantages must go to those who are able to satisfy the consumer's requirements. Should the herd fail to provide the necessary supply, new cattle must be purchased or the farmer loses his market. In practically every milk market in Ontario the producer has a quota, which must be shipped daily. This quota is based on the producer's ability to ship high quality milk regularly according to the requirements of the market. The greater the market, the greater the area from which milk comes. The average shipping cost to Toronto is about 30c per hundred while in other markets the shipping cost is a half or a third of that amount.

To the uninstructed, milk is milk. There is a growing conviction, however, that milk is no better than the feed which the cow receives. In other words, if sufficient minerals and vitamins are not in the cow's feed, the milk will be

deficient. Certain vitamins are present in larger amounts in milk when the cows are on proper pasture and enjoying sunshine than when they are in winter quarters and are fed on poor quality ration.

It is obvious, therefore, that the producer of this high-quality health food must constantly receive at least the cost of production for his product. The continuance of a constant supply is dependent on this, but more especially bankrupt producers cannot be expected to pay the attention necessary to produce a quality product. Through ignorance many consumers still look upon milk as milk, and hence the producer equipped to supply safe milk has little or no protection from the producer who makes no serious effort to produce milk of a satisfactory quality. The milk-control legislation in the several Provinces of Canada provides an answer to this problem. At no time has the Milk Producers' Association been able to control all the shippers to a market, nor has the Milk Distributors' Association been able to control all the distributors. Proper legislation accomplishes adequate control.

The Ontario Whole Milk Producers' League, which is a federation of sixty local markets organized provincially, has co-operated with other provincial dairy farm organizations to determine the cost of producing one hundred pounds of milk. The work has been done under the supervision of the Federal Department of Agriculture, Economics Branch, and the Ontario Agricultural College. More than a thousand dairy farmers in Ontario have been keeping records based, not on the cost of producing feed for dairy cattle, but on the market value of the feed used. These studies, when completed, will be most interesting and will be a basis of arriving at the increased cost borne by those producing an even supply of milk, as well as the actual cost of producing milk in any area. The studies are a cross-section of the whole milk production of the Province. With this information and with the assistance of milk-control legislation, it is anticipated that the regular producer of high-quality milk may be able to secure a reasonable return for the contributions that he makes to the well-being of his fellow-citizens.

THE LANCET AND PASTEURIZATION*

WHAT is needed is not inquiry but action. It may not be administratively possible to pasteurize the whole milk-supply at once, but it is certainly feasible that all the larger urban areas should have the power—and we hope the duty—to see that only safe milk is sold within their borders. Tuberculin-tested milk gives this safety, as regards tuberculosis; and pasteurization, properly conducted, gives safety from all risks. The time has come when no ordinary raw milk should be sold in any of our larger urban areas or distributed on the authority of any education or other local authority. And later the safeguard must be extended to the countryside and smaller towns.

Editorial, July 17, 1937, page 143.

Milk-Control Legislation in Canada

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LEGISLATION for the control of fluid milk supplies is both a municipal and a provincial responsibility. Local by-laws are passed in municipalities under authority given by provincial statutes. These deal with licensing and a variety of other details. Provincial legislation varies considerably, but recently there has been a noticeable trend to establish definite standards, and more direct control over distributing plants. Milk production and supervision have been left largely to local centres. Ontario is the first province to adopt a compulsory pasteurization law.

British Columbia

The Provincial Board of Health has power to adopt and enforce through the local boards any regulations regarding the production and sale of milk. Standards for pasteurization are not contained in the Act or the Regulations. The administration of the Milk Act comes under the Department of Agriculture.

Alberta

Comprehensive regulations have been passed in Alberta, under authority of the Public Health Act, for the control of dairy farms and the processing and distribution of milk.

Milk and its products are defined. Pasteurization is defined as 142°-145° F. for thirty minutes with immediate cooling to 45° F. Correct labelling of the bottle contents is required in print of 10-point type. A certificate of registration from the local board of health is required for the sale of milk. This is renewable annually, with prescribed conditions. Every milk producer or person owning one or more milch cows must obtain a certificate of registration from the local board of health. This calls for an inspection. The requirements for producers' premises and equipment are specified. Where the bacterial count exceeds 100,000 per cc., the producer must make any changes required by the local board of health. Processing plants also require approval or certificate of registration from the local board of health. The personnel of such plants may be asked by the board to undergo medical examination. Requirements are listed for the equipment of dairies.

Saskatchewan

Regulations respecting milk and milk products have been passed by the Province of Saskatchewan. These deal with the production, processing and sale of milk.

Pasteurization is defined as heating between 145° and 150° F. for not less than thirty minutes. Pasteurized milk must not contain more than 100,000 bacteria in summer or more than 50,000 in winter. No milk is to be pasteurized more than once. Emphasis is placed on the labelling of the container in type of 10-point size. The Regulations contain clauses on stables, milk-houses, and the general routine. Where cows have been tested for tuberculosis or contagious abortion, positive reactors must be removed from the herd, and the milk from the remaining cows must be pasteurized for a period of sixty days and until all cows have been certified as being free from these diseases. Plans for proposed pasteurization plants or alterations to existing ones must be submitted to the Minister of Health for his approval.

MANITOBA

The Public Health Act of the Province of Manitoba contains a number of clauses dealing with the control of milk and all milk products. These products are defined in detail. Pasteurization is defined as 143° F. for thirty minutes, and all plants used for this purpose are subject to inspection by the Provincial Department of Health and Public Welfare. A licence is required from the Minister of Health and plans of buildings and equipment must be filed with him. Standards for milk pasteurization and subsequent handling of the product are issued by the Department of Health and Public Welfare. An annual certificate is required for all employees coming in contact with the pasteurization of milk. Licences from the local board of health or the Minister of Health are required by producers and distributors of all dairy products. Specific standards are laid down for milk production. Milk depots or buildings for processing and distributing milk must be approved by the local health officer and must contain at least four rooms, with one being set aside for processing. Other dairy products must not be handled in this room.

The Province of Manitoba has complete supervision over milk supplies.

ONTARIO

In the Province of Ontario considerable legislation has been passed for the control of milk supplies. The Milk and Cream Act, in force for many years, sets certain provincial standards and authorizes local municipal councils to pass by-laws for regulating the production and handling of milk. This has been supplemented by the Milk Control Act and by Regulations passed thereunder. This legislation involves licensing by the Milk Control Board of all distributing plants, raw and pasteurizing. Definite standards are set for both types of dairies. The work of inspection is conducted by the Provincial Department of Health, but the licences are issued by the Milk Control Board.

Pasteurization is defined as 143° F. for thirty minutes. The plans for all pasteurizing plants must be approved by the Department of Health before work is undertaken. All containers for milk must be labelled either "raw milk" or "pasteurized", as the case may be. Further legislation has been passed during

the latest session (1938) prohibiting the sale of any but pasteurized milk in all towns and cities and such other areas as may be designated by the Provincial Department of Health. This legislation is to come into effect when so declared. The same standards for plants will apply as under the milk control regulations. Each plant must be approved by the Department of Health and a certificate be issued for each. Supervision of milk production is left to the municipalities. The pertinent legislation is as follows:

PASTEURIZATION OF MILK*

95a.—(1) No person shall sell, offer for sale, or deliver in any city or town, or in any other municipality or other area to which by order-in-council made upon the recommendation of the Minister this section is made applicable, milk which has not been pasteurized in a pasteurization plant to which the Department has issued a certificate of approval in the prescribed form.

(2) This section shall not apply to milk brought into any such city, town, municipality or area by the producer and sold by wholesale to a distributor, nor to products of milk prepared in a plant and by methods approved by the Department.

(3) Any medical officer of health, sanitary inspector and any person authorized by a medical officer of health may, without laying any information or obtaining any warrant, seize and remove any milk sold, offered for sale or delivered, including any container in which such milk is found, for the purpose of causing an analysis of such milk to be made.

(4) Any person who contravenes any of the provisions of this section shall incur a penalty of not less than $25 nor more than $500.

QUEBEC

The Quebec Public Health Act makes specific reference to pasteurization of milk. The process is defined as 145° F. for thirty minutes, with subsequent cooling to 50° F. No pasteurizing plant can be installed nor any existing plant altered until plans and specifications have been submitted to and approved by the Minister of Health. The Minister has the authority to investigate the operation of all pasteurizing plants and to order such changes as he may deem necessary to obtain efficient results. Persons employed in pasteurization plants may be required to undergo medical examinations as required by the Ministry of Health. Local health authorities are authorized to examine dairies and stables and to prohibit the sale of milk therefrom if they are insanitary.

NOVA SCOTIA

The Public Health Act of Nova Scotia contains clauses relating to the production and processing of milk. Bacterial standards are included. No milk sold or shipped is to contain more than 50,000 bacteria in summer or 30,000 for the remainder of the year as it leaves the producer's milk house. Pasteurization is defined as between 142° and 148° F. for twenty-five to thirty minutes. Milk must not contain more than 200,000 bacteria before pasteurization and not

An Act to amend the Public Health Act, Chapter 30. Assented to April 8, 1938.

more than 30,000 after treatment. Pasteurized milk must not be sold when it is more than thirty-six hours old, and repasteurization is not permitted. Pasteurized milk must be distributed in properly labelled bottles. The process of pasteurization is subject to inspection by the local health officer or any inspector appointed by the Minister of Health. Self-recording thermometers must be placed on pasteurizers if the Minister of Health so requires.

NEW BRUNSWICK

In New Brunswick regulations are in force for "Dairies and Milk". The sub-district board of health of each sub-health district is given authority to inspect cows and premises. Minimum standards are set for milk, its production and sale. Other requirements not at variance with these may be formulated by sub-district boards of health.

PRINCE EDWARD ISLAND

Regulations governing the inspection of dairy farms and cows are in force. These define the requirements for the stables, milk house and the milking.

DOMINION LEGISLATION

The Dominion legislation has little to do with fluid milk, but the Food and Drugs Act refers to milk products and their labelling, adulteration and composition.

THE LEAGUE OF NATIONS' MILK COMMITTEE AND PASTEURIZATION*

IT is important to distinguish between the terms "clean" and "safe" in relation to milk. Clean milk is milk that is free from extraneous matter such as manure and dust, from blood, and from an undue number of leucocytes and bacteria. Safe milk is milk that is free from bacteria capable of giving rise to disease in man or animals.

Though many pseudo-scientific objections have been advanced against it, we have been unable to find any that is supported by adequate evidence. On the other hand, there is a considerable amount of evidence to show that, when pasteurization has been introduced on a large scale, milk-borne disease has been practically abolished. There is a reason to believe that, if pasteurization was rendered compulsory for all towns, infection derived from milk would be completely prevented. In country districts, where compulsory pasteurization is impracticable, insistence should be laid on the necessity of boiling milk prior to consumption.

The public health value of pasteurization has now outstripped its commercial importance. A long keeping quality can be guaranteed by cleanliness of production but no amount of cleanliness can ensure the freedom of the milk from disease-producing organisms. For this purpose pasteurization or some other form of heat treatment appears under ordinary conditions to be indispensable.

Bulletin of the Health Organisation, League of Nations, June 1937.

A Survey of Milk Control in Cities and Towns in Canada

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THE late Mr. R. H. Murray compiled data concerning the extent of pasteurization in the larger cities of Canada, publishing his report in 1936.

To learn the progress in the movement for the pasteurization of all milk supplies, letters were sent to medical officers of health throughout Canada. Information was sought concerning the present situation in regard to pasteurization in each municipality. It was desired particularly to learn if pasteurization of milk was compulsory and the date of such enactment. Realizing that in some municipalities pasteurization of all milk supplies was being carried out without a compulsory by-law, specific enquiry was made. In the table several municipalities are recorded in which this situation pertains. A second major question related to the distribution of milk. Data were sought concerning the number of pasteurizing plants within the municipality and the number of such plants outside the municipality. This information was desirable because in a number of municipalities a major part of the supply is received from dairies outside the municipality. Information concerning the number of raw-milk dairies distributing milk in the municipality was also requested, together with the total amount of fluid milk distributed daily (including raw and pasteurized) and the amount of milk which was pasteurized daily expressed either in quantity or as a percentage. Questions relating to the testing of dairy cattle, both for tuberculosis and contagious abortion, were included. It was desired in each instance to learn if compulsory testing was in force and the dates of such enactments. As the information was to be supplied by medical officers of health, enquiry was made also concerning the occurrence of typhoid fever or other communicable diseases. The data kindly supplied in regard to the occurrence of these diseases was included in the survey of milk-borne diseases which appears in this issue. The response on the part of the medical officers of health was excellent.

The data concerning the extent of pasteurization, supervision of herds, etc., are presented in table I, as relating only to the municipalities having a population greater than 2,000. Many smaller municipalities have complete pasteurization or have a large percentage of their milk pasteurized. As it was not possible to publish the entire list, the data relating to the smaller municipalities will be published later.

Summarizing the information concerning pasteurization, it is interesting to record the present status in regard to complete pasteurization of the municipalities of 2,000 and over in the various Provinces. In British Columbia and

TABLE I

MILK CONTROL IN CITIES AND TOWNS IN CANADA, 1938

Including the extent of pasteurization, volume of milk distributed, and supervision of herds in municipalities having a population of more than 2,000

Municipality	Population	Pasteurization		Pasteurizing Plants	Raw Milk Plants	Amount of Milk Daily	Percentage Pasteurized	Tbc. Testing	Bang's Disease Testing
		Complete	Compulsory						
	(1931)								
British Columbia									
Burnaby	25,564	No	No	Vancouver	10	—	—	Yes	No
Cranbrooke	3,067	—	No	1	5	—	—	Yes	No
Fernie	2,732	No	No	—	7	275 gals.	—	Yes	No
Kamloops	6,167	No	No	0	16	500 gals.	0	Yes	No
Kelowna	4,655	—	—	—	—	—	—	—	—
Nanaimo	6,745	No	No	0	26	—	—	Yes	Yes
Nelson	5,992	No	No	2	—	—	40	Yes	—
New Westminster	17,524	—	—	—	—	—	—	—	—
Oak Bay	5,892	No	No	4	47	—	—	Yes	No
Penticton	4,640	No	No	1	12	329 gals.	24	No	No
Prince Rupert	6,350	No	No	1	3	—	—	No	No
Revelstoke	2,736	No	No	0	5	—	0	Yes	—
Trail	7,573	No	No	1	12	—	35	Yes	No
Vancouver	246,593	No	No	22	55	—	78	Yes	—
Victoria	39,082	No	No	4	—	—	30	Yes	—
Alberta									
Calgary	83,761	No	No	5	20	23,770 qts.	84	Yes	No
Edmonton	79,197	No	No	6	42	46,800 pts.	77	Yes	No
Lethbridge	13,489	No	No	2	7	3,400 qts.	50	Yes	No
Medicine Hat	10,300	No	No	—	—	—	Part	No	No
Montgomery	3,329	No	No	2	—	—	—	No	No
Saskatchewan									
Biggar	2,369	No	No	1	4	—	—	Yes	Yes
Moose Jaw	21,299	No	No	3	4	5,190 qts.	93	Yes	Yes
North Battleford	5,986	Yes	Yes	3	0	1,478 qts.	100	Yes	Yes
Prince Albert	9,905	No	No	3	1	—	92	No	—
Regina	53,209	No	No	—	—	—	Part	Yes	No
Saskatoon	43,291	Yes	Yes	4	0	40,000 lbs.	100	Yes	No
Swift Current	5,296	No	No	2	6	1,360 qts.	63	Yes	No
Weyburn	5,002	No	No	—	—	—	Part	Yes	No
Yorkton	5,027	No	No	—	—	—	—	Part	Yes
Manitoba									
Brandon	17,082	No	No	2	18	3,200 qts.	60	Yes	No
Dauphin	3,971	No	No	—	—	—	30	Yes	—
Portage La Prairie	6,597	No	No	2	6	1,000 qts.	60	Yes	No
St. Boniface	16,305	No	No	—	—	—	0	—	—
The Pas	4,030	No	No	—	—	—	30	Yes	—
Transcona	5,747	No	No	2	58	—	—	No	No
West Kildonan	6,132	No	No	—	7	—	60	Yes	Yes
Winnipeg	218,785	No	No	9	90	18,000 gals.	78	Yes	No
Ontario									
Alexandria	2,006	No	No	1	4	450 qts.	33	No	No
Almonte	2,415	No	No	0	5	350 qts.	0	Yes	Yes
Amherstburg	2,759	No	No	2	3	750 qts.	20	No	No
Arnprior	4,023	No	No	1	7	1,093 qts.	36	Yes	No
Aurora	2,587	Yes	Yes	2	0	760 qts.	100	Yes	Yes
Barrie	7,776	Yes	Yes	4	0	3,000 qts.	100	No	No
Belleville	13,790	No	No	6	6	5,322 qts.	90	No	No
Blind River	2,805	No	No	0	6	600 qts.	0	Yes	Yes
Bowmanville	4,080	No	No	2	1	1,130 qts.	94	No*	No*
Bracebridge	2,436	No	No	2	2	160 gals.	81	No	No
Brampton	5,532	No	No	3	3	—	—	Yes	No
Brantford	30,107	Yes	Yes	7	0	13,376 qts.	100	No	No
Brockville	9,736	Yes	No	8	0	4,000 qts.	100	Yes	Yes
Burlington	3,046	No	No	4	1	1,000 qts.	—	Yes	No
Campbellford	2,744	No	No	2	3	—	70	Yes	No
Carleton Place	4,105	No	No	2	2	1,300 qts.	92	No	No
Chatham	14,569	No	No	4	2	5,336 qts.	95	Yes	No
Cobourg	5,834	No	No	3	—	1,750 qts.	84	Yes	No
Cochrane	3,963	No	No	1	5	800 qts.	12	Yes	No
Collingwood	5,809	No	No	4	5	—	—	Yes	No
Copper Cliff	3,173	Yes	Yes	1	0	1,100 qts.	100	No	No
Cornwall	11,126	No	No	5	14	6,500 qts.	85	—	—
Dundas	5,026	Yes	Yes	0	0	1,300 qts.	100	No	No
Forest Hill	5,207	Yes	—	—	—	—	—	No	No
Fort Erie	5,904	Yes	Yes	7	0	1,200 qts.	100	No	No
Fort Frances	5,470	No	No	1	10	2,500 qts.	25	Yes	No
Fort William	26,277	No	No	9	9	1,800 gals.	87	Yes	No
Galt	14,006	Yes	Yes	4	0	4,000 qts.	100	No	No
Gananoque	3,592	No	No	2	3	1,250 qts.	68	Yes	Yes

—Indicates information not supplied.
* Voluntarily undertaken (not compulsory).

TABLE I—*continued*

Municipality	Population	Pasteurization		Pasteurizing Plants	Raw Milk Plants	Amount of Milk Daily	Percentage Pasteurized	Tbc. Testing	Bang's Disease Testing
		Complete	Compulsory						
	(1931)								
Georgetown	2,288	No	No	2	6	190 gals.	71	Yes	No
Grimsby	2,198	Yes	Yes	2	0	500 qts.	100	No	No
Guelph	21,075	No	No	4	13	6,668 qts.	70	Yes	No
Hamilton	155,547	Yes	Yes	22	0	14,688 gals.	100	No	No
Hanover	3,077	No	No	2	1	850 qts.	98	No	No
Hawkesbury	5,177	No	No	0	10	1,200 qts.	0	Yes	No
Hespeler	2,752	No	No	2	3	400 gals.	75	No	No
Humberstone	2,490	No	No	5	—	954 qts.	98	No	No
Ingersoll	5,233	No	No	2	6	1,655 qts.	79	—	—
Kenora	6,766	No	No	2	16	2,750 qts.	36	Yes	No
Kingston	23,439	Yes	Yes	11	0	9,600 qts.	100	No	No
Kitchener	30,793	No	No	12	2	20,256 pts.	99	No	No
Lindsay	7,505	No	No	4	3	—	—	Yes	Yes
Listowel	2,676	No	No	5	3	600 qts.	75	No	No
London	71,148	No	No	18	18	25,200 qts.	95	Yes	Yes
Long Branch	3,962	Yes	Yes	12	0	—	100	Yes	Yes
Meaford	2,624	Yes	Yes	2	0	600 qts.	100	Yes	Yes
Midland	6,920	No	No	3	4	1,255 qts.	65	No	No
Mimico	6,800	Yes	Yes	1	0	—	100	—	—
Newmarket	3,748	Yes	Yes	3	0	45 cans	100	Yes	No
New Toronto	7,146	Yes	Yes	8	0	—	100	No	No
Niagara Falls	19,046	Yes	Yes	7	0	9,500 qts.	100	No	No
North Bay	15,528	Yes	Yes	5	0	4,000 qts.	100	No	Yes
Oakville	3,857	Yes	Yes	3	0	1,620 qts.	100	Yes	No
Orillia	8,183	Yes	Yes	8	0	3,200 qts.	100	No	No
Oshawa	23,439	Yes	Yes	6	0	7,294 qts.	100	Yes	No
Ottawa	126,872	No	No	13	2	18,000 gals.	99	Yes	No
Owen Sound	12,839	No	No	4	8	4,500 qts.	91	Yes	No
Parry Sound	3,512	No	No	1	3	865 qts.	58	No	No
Pembroke	9,368	No	No	2	6	2,800 qts.	77	No	No
Penetang	4,035	No	No	2	20	1,200 qts.	60	Yes	No
Perth	4,099	No	No	1	6	1,280 qts.	47	No	No
Peterborough	22,327	No	No	6	21	9,664 qts.	83	Yes	Yes
Petrolia	2,596	No	No	2	1	575 qts.	87	No	No
Picton	3,580	No	No	2	7	1,200 qts.	50	Yes	No
Port Arthur	19,818	No	No	3	13	4,520 qts.	87	—	—
Port Colborne	6,503	Yes	Yes	5	0	2,250 qts.	100	No	No
Port Hope	4,723	No	No	4	—	1,500 qts.	95	Yes	No
Prescott	2,984	No	No	2	2	700 qts.	75	Yes	No
Preston	6,280	No	No	4	3	1,525 qts.	72	—	—
Renfrew	5,296	No	No	4	4	1,550 qts.	75	Yes	No
St. Catharines	24,753	Yes	Yes	9	0	11,000 qts.	100	Yes	No
St. Mary's	3,802	No	No	3	2	1,000 qts.	80	Yes	No
St. Thomas	15,430	No	No	6	6	8,000 qts.	85	Yes	No
Sarnia	18,191	No	No	5	7	6,920 qts.	84	Yes	—
Sault Ste. Marie	23,082	No	No	4	32	5,500 qts.	70	Yes	No
Simcoe	5,226	—	Yes	2	0	—	98	No	No
Sioux Lookout	2,088	No	No	0	5	335 qts.	0	Yes	No
Smiths Falls	7,108	No	No	4	4	2,000 qts.	75	Yes	No
Stratford	17,742	No	No	4	5	4,420 qts.	25	No	No
Sudbury	18,518	Yes	—	5	0	6,900 qts.	—	—	—
Swansea	5,031	Yes	—	—	—	—	100	—	—
Tecumseh	2,129	No	No	6	1	500 qts.	60	No	No
Thorold	5,092	Yes	Yes	5	0	2,220 qts.	100	No	No
Timmins	14,200	Yes	—	5	0	6,790 qts.	100	—	—
Toronto	631,207	Yes	Yes	53	0	74,000 gals.	100	No	No
Trenton	6,276	No	No	3	4	1,730 qts.	75	—	—
Waterloo	8,095	No	No	3	1	2,000 qts.	90	—	—
Welland	10,709	Yes	Yes	5	0	3,950 qts.	100	No	No
Weston	4,723	Yes	Yes	11	0	—	100	Yes	No
Whitby	5,046	No	No	5	12	800 qts.	No	No	No
Windsor	98,203	Yes	Yes	12	0	10,000 gals.	100	No	No
Woodstock	11,395	No	No	4	5	3,724 qts.	83	—	—
Quebec									
Chicoutami	11,877	No	No	1	11	500 gals.	30	Yes	No
Dolbeau	2,032	Yes	Yes	2	0	130 gals.	100	Yes	No
Drummondville	6,609	Yes	—	4	0	725 gals.	100	Yes	—
Farnham	4,205	No	No	1	8	12,00 qts.	25	Yes	Yes
Granby	10,587	No	No	1	39	3,500 qts.	17	Yes	Yes
Grand 'Mere	6,461	No	No	—	—	—	0	No	—
Hull	29,433	No	No	1	—	500 gals.	30	—	—
Joliette	10,765	No	No	—	—	—	0	No	—
Jonquiere	9,448	No	No	2	—	225 gals.	40	—	—
Kenogami	4,500	No	No	6	2	1,700 qts.	82	Yes	No
Lachine	18,630	Yes	Yes	—	—	2,000 gals.	100	Yes	Yes
La Malbaie	2,408	No	No	1	—	150 gals.	30	—	—
La Tuque	7,871	No	No	—	—	—	0	No	—
Lauzon	7,084	No	No	—	—	—	0	No	—
Levis	11,724	No	No	—	—	100 gals.	10	—	—
Longueuil	5,407	No	No	1	—	3,200 qts.	35	—	—

— Indicates information not supplied.
* Vcluntarily undertaken (not compulsory).

TABLE I—*continued*

Municipality	Population	Pasteurization		Pasteurizing Plants	Raw Milk Plants	Amount of Milk Daily	Percentage Pasteurized	Tbc. Testing	Bang's Disease Testing
		Complete	Compulsory						
Magog	6,302	No	No	1	—	60 gals.	10	—	—
Montreal	818,577	No	No	30	40	68,353 gals.	94	Yes	No
Noranda	2,246	No	No	1	—	140 gals.	70	—	—
Pointe Claire	4,058	No	No	5	10	—	—	No	No
Quebec	130,594	No	No	6	—	5,200 gals.	50	—	—
Rimouski	5,589	No	No	—	—	—	0	No	—
Riviere Du Loup	8,499	No	No	—	—	—	0	No	—
Rouyn	3,225	No	No	2	—	300 gals.	70	—	—
S.Agathe des Monts	2,949	No	No	1	—	150 gals.	30	—	—
S. Anne de Bellevue	2,417	No	No	1	—	100 gals.	40	—	—
St. Hyacinthe	13,448	No	No	1	27	1,500 gals.	13	Yes	No
St. Jean	11,256	No	No	4	—	800 gals.	70	—	—
St. Jerome	8,967	No	No	2	5	700 gals.	71	Yes	No
St. Joseph d'Alma	3,970	No	No	1	—	50 gals.	30	—	—
St. J. de Grantham	2,812	No	No	1	—	150 gals.	30	—	—
St. Lambert	6,075	No	No	2	—	450 gals.	80	—	—
St. Laurent	5,348	No	No	2	—	1,500 gals.	20	—	—
Shawinigan Falls	15,345	No	Yes	1	0	5,000 qts.	38	Yes	No
Sherbrooke	28,933	No	No	1	81	2,225 gals.	19	No*	No
Sorel	10,320	No	No	1	—	60 gals.	10	—	—
Thetford Mines	10,701	No	No	—	—	—	0	No	—
Three Rivers	35,450	No	No	3	—	1,600 gals.	40	—	—
Valleyfield	11,411	No	No	—	—	—	0	No	—
Verdun	60,745	Yes	Yes	—	0	4,600 gals.	100	Yes	Yes
Victoriaville	6,213	No	No	1	75	1,850 qts.	32	Yes	—
New Brunswick—(Tuberculosis—free area)									
Campbellton	6,505	No	No	—	—	1,800 qts.	33	—	—
Fredericton	8,830	No	No	—	—	4,000 qts.	20	—	—
Moncton	20,689	No	No	—	—	8,800 qts.	18	—	—
Saint John	47,514	No	No	—	—	18,400 qts.	90	—	—
Nova Scotia									
Amherst	7,450	No	No	1	34	—	5	Yes	No
Bridgewater	3,262	—	—	1	—	—	—	—	—
Dartmouth	9,100	—	—	2	—	—	—	—	—
Halifax	59,275	No	No	6	15	20,000 qts.	80	No	No
Kentville	3,033	—	—	1	—	—	75	—	—
New Glasgow	8,858	—	—	1	—	—	—	—	—
Springhill	6,355	—	—	1	—	—	—	—	—
Stellarton	5,002	—	—	1	—	—	—	—	—
Sydney	23,089	No	No	6	30	10,000 qts.	50	No	No
Sydney Mines	7,769	—	—	1	—	—	—	—	—
Truro	7,901	—	—	3	—	—	—	—	—
Windsor	3,032	—	—	1	—	—	—	—	—
Yarmouth	7 055	No	No	3	7	—	—	No	No

— Indicates information not supplied.
* Voluntarily undertaken (not compulsory).

Alberta there are no cities or towns having either complete or compulsory pasteurization. Data were received concerning 9 municipalities in British Columbia and 4 municipalities in Alberta in which pasteurization is conducted in part. In Saskatchewan the municipalities of North Battleford and Saskatoon have compulsory pasteurization. Reports also indicate that pasteurization was conducted in 4 other municipalities. In the city of Moose Jaw it was expected that compulsory pasteurization would be enacted on May 1st. In Manitoba there are no municipalities having compulsory pasteurization but the data indicate that pasteurization is conducted in at least 4 municipalities. Pasteurized milk is also supplied to the several municipalities adjacent to Winnipeg. In Ontario prior to the recent legislation which will prohibit the sale of raw milk in towns and cities, a large number of municipalities had adopted local by-laws requiring pasteurization. A total of 52 municipalities had complete pasteurization. Of the municipalities of 2,000 population and over, 32 had achieved 100 per cent. pasteurization. In Quebec 4 centres reported complete pasteurization, and

pasteurization is conducted in at least 29 other centres. In New Brunswick the reports indicated that 4 centres have some pasteurization, the city of Saint John having approximately 90 per cent. of the milk pasteurized. In Nova Scotia 3 centres which forwarded reports recorded the pasteurization of part of the milk distributed.

The table presents in part the information that was received. It is hoped that similar data may be obtained for all municipalities and that it will be possible to record a further advance in the number of municipalities having complete pasteurization.

THE CANADIAN PUBLIC HEALTH ASSOCIATION AND PASTEURIZATION*

THE CANADIAN PUBLIC HEALTH ASSOCIATION stands unequivocally for the pasteurization of all milk supplies as the one and only means at our disposal for the final safeguarding of the health of the public from the dangers associated with the consumption of raw milk. This position has been stated and re-affirmed by resolutions at succeeding annual meetings of the Association. In so emphasizing the place of pasteurization in an adequate system of milk control, the Association has not overlooked the fundamental importance of proper inspection of dairy farms and dairy plants, with all that this inspection entails. It is fully recognized that pasteurization can only render a milk safe from the danger of disease transmission. Pasteurization cannot make a dirty milk clean or guarantee that a milk is properly collected. The importance of inspection of the raw milk and its source cannot be over-stressed, but, granted complete inspection, the public cannot be safeguarded unless the milk is properly pasteurized. The necessity for general pasteurization is amply demonstrated every year in our high death-rates from diarrhoea and enteritis, in our milk-borne typhoid epidemics or septic sore throat epidemics, the increasing cases of undulant fever, and our cripples from bovine tuberculosis. Our objective must be safe, clean, wholesome milk. Proper pasteurization is the only means of assuring protection against milk-borne disease.

**Resolution passed at a meeting of the Executive Committee, Toronto, June, 1935.*

Cleansing and Disinfecting Operations in a Small Dairy

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IN the manufacture of all food products, the maintenance of clean, hygienic conditions of plant and processing equipment is desirable. Because of its susceptibility to bacterial contamination, this requirement is most important in the processing of milk for domestic use.

It is now generally conceded that cleansing and disinfecting are two separate processes. "Cleansing" refers to the process whereby an unclean surface is subjected to the action of a detergent solution to remove all visible dirt. By "disinfection" is meant the subsequent treatment necessary to destroy the remaining bacterial or invisible contamination. The word "disinfection" as employed in the dairy industry does not mean the destruction of all bacterial life but rather the killing of all pathogenic organisms and the reduction of other forms to an economic minimum. Thorough cleansing is a necessary prerequisite to disinfection. This point cannot be too strongly emphasized.

The remarks which follow apply to operations in both "raw milk" and "pasteurizing" plants. The same degree of care should be exercised in the operation of both types of plant. Where the milk is pasteurized, there is more equipment which must be kept clean. Steam is also available for disinfecting purposes. This disinfecting agent is frequently lacking in raw milk plants.

Plant and Equipment Design and Construction Important

The primary requisite to ensure a sanitary dairy is the possession of a plant and equipment which can be readily cleaned. The desire of the intelligent dairyman for cleanliness will influence his choice of construction materials for the building and his selection of equipment for processing. The essential features covering these matters are embodied in the Ontario regulations passed under the authority of the Milk Control Act.

Choice of Washing Powder

There are many washing compounds on the market for dairy use. Generally speaking, they contain one or more of the following chemicals: sodium carbonate, tri-sodium phosphate and sodium hydroxide. Recently the use of metasilicate compounds has been increasing. The compound should be a good detergent and should have good rinsing properties. For hand washing, it is essential that it be free from hydroxide, whereas for mechanical washing the use of a powder containing hydroxide is desirable. The choice, as a rule, depends largely upon

the preference of the individual dairyman, based upon his observations of the results secured under operating conditions with which he is familiar.

DISINFECTING AGENTS

Disinfection is effected by means of the application of steam, hot water, a chemical sterilizer, or some combination of these. The efficiency of steam sterilizing will depend upon such factors as steam pressure, volume of steam used, period of steaming, final temperature and the length of time the steamed object remains at this temperature. The efficiency of chemical disinfection will depend upon the chemical composition of the bactericide, the strength and temperature of the bactericidal solution and the period of contact.

During the past few years, the use of chlorine compounds as disinfecting agents either when used alone or in conjunction with steam or hot water has increased to a marked degree. In the smaller plants, where steam is not available, their use is strongly recommended.

CLEANSING AND STERILIZING EQUIPMENT

The equipment should be cleansed immediately following the completion of processing operations. After first rinsing with cold or lukewarm water, it should be washed and brushed thoroughly with the warm washing solution. The strength should be at least ¼ per cent. of a powder which does not contain free hydroxide. After washing, the equipment should be again rinsed with clean warm water. For cleansing, all piping and demountable apparatus should be dismantled daily. Racks or other arrangements should be provided for storing these until time for assembly the following day.

After thorough washing, the equipment must receive a satisfactory bactericidal treatment. Steam, hot water or a chlorine solution may be used. It is important that, whatever the method employed, the treatment be adequate. In the case of steam and hot water, the temperature and contact period are important factors. Where a chlorine solution is used, the solution strength and contact period are controlling factors. A solution containing at least 100 parts per million available chlorine and a contact period of at least two minutes are recommended. Many dairy operators have provided a metal tank or trough for storing piping, valve fittings, etc., after cleansing. This material is stored in the tank immersed in a chlorine solution of at least 50 parts per million. The regulations of the Milk Control Act of Ontario also require that the processing equipment receive a satisfactory bactericidal treatment immediately prior to the commencement of the day's operations. A warm solution containing 50 parts per million available chlorine is commonly used. This is pumped through or over all of the processing equipment. Steam or hot water, however, may be used. Exposed valves and open ends of piping should be thoroughly steamed before they are connected.

BOTTLE WASHING AND DISINFECTING

Bottles may be washed by hand or machine. There are two main types of mechanical equipment—pressure hydraulic case washers and "soaker" machines. Each of these classes represents an extensive range of individual machines of varied design.

The method used is governed primarily by the daily output. Hand washing is universal in the small dairies and prevalent in plants with a daily output up to 200 gallons. Pressure hydraulic case washers are commonly used in dairies with daily distribution up to 2,000 gallons, while the soaker type machines may be found in plants bottling from 800 gallons a day. In recent years, smaller machines of the soaker type have come on the market which permit their installation in dairies with a lesser output.

Owing to the great variety of methods and equipment used, it is difficult to formulate a set of hard and fast rules. Differences in the design of this equipment and the nature of the detergent and sterilizing media used make each dairy an individual problem which must be solved by the correlation of local factors.

For hand washing, where steam is not available, the bottle washing equipment should consist of a motor-driven brush and a three-compartment wash and rinse tank. The washing compound should not contain free hydroxide and a solution strength of from ¼ to ½ per cent. by weight is recommended. After washing and brushing, the bottles should be rinsed first in warm water and then disinfected by total immersion for at least two minutes in a solution containing at least 50 parts per million available chlorine. The temperature of the wash and rinse waters should not be less than 110°F. If steam is available, a single-case steam sterilizer may be substituted for the chlorine-rinse tank. The bottles should be steamed for at least 30 seconds at 40 lbs. steam pressure or receive equivalent treatment.

For pressure hydraulic case washers, a wash solution of at least 0.6 per cent. by weight of a compound containing a minimum of 60 per cent. sodium hydroxide is advised. Minimum temperatures recommended are: pre-rinse, 90°F.; wash solution, 120°F.; first rinse, 150°F. and second rinse, 180°F. The operating speed should not exceed the rated capacity of the machine. If a chlorine rinse is used, it should have a strength of not less than 100 parts per million. The tanks should be dumped and recharged daily. All very dirty bottles should be brushed first on a motor-driven rotary brush.

In the "soaker" type washer, a washing compound similar to that used for pressure hydraulic case washers is recommended. The average percentage of free hydroxide in the wash solution should not be less than 2.5. The concentration should be checked by the operator by an approved method of chemical titration and the solution made up to strength daily. The minimum temperature of the wash solution in the single compartment machine should be 120°F. In multiple compartment equipment, the bottles should reach a temperature of at least 150°F. If there is a final chlorine rinse, it should contain not less than 25

parts per million available chlorine. The solution tanks of single compartment machines should be dumped and recharged at least every two weeks, and of multiple compartment machines at least once per month.

CAN WASHING AND STERILIZING

In the smaller dairies the cans are usually washed by hand. They should first receive a cold or warm water rinse and then be washed and brushed with warm water containing a good washing powder. Care should be taken that the shoulder of the can is satisfactorily cleansed. After washing, the cans should receive a clean water rinse and then be sterilized. Steam is most commonly used for this purpose. It is important that a dry can be returned to the producer and metal racks on which the cans can be inverted for a period sufficiently long to ensure this, are desirable.

Mechanical equipment of various types is also available for can washing in the larger dairies. Satisfactory performance of this equipment depends upon such factors as proper strength of wash solution, adequate temperatures and efficient operation.

DETERMINATION OF EFFICIENCY OF WASHING AND DISINFECTING OPERATIONS

A periodic check of the efficiency of the washing and disinfecting operations is advisable. Visual examination is of little value, and some laboratory test is essential. In the case of the equipment, laboratory tests of samples of the milk which first passes through or over it will generally disclose ineffective treatment. With bottles, cans and other containers, the test most commonly employed consists of rinsing the cleansed container with a known quantity of sterile water and making standard plate counts on this rinse water. This gives an approximation of the number of colony-producing bacteria removed from the container. This test, while not entirely satisfactory, will detect the majority of instances of unsatisfactory disinfection. Where chlorine compounds are used for sterilizing, the plant operator and the local inspector should be familiar with and should use the orthotolidin test for the detection of free chlorine.

CLEANLINESS OF PERSONNEL

Not the least important of the factors which ensure cleanliness in the dairy is the provision which is made for the personal cleanliness of the plant personnel. Sections 24 and 69 of the regulations issued under the authority of the Milk Control Act in Ontario enumerate the requirements in this respect. They include adequate hand washing facilities and satisfactory toilets. These accommodations should be maintained in a clean and sanitary condition.

Engineering Defects in Dairies

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MILK-DISTRIBUTING plants require a good deal of mechanical equipment and the tendency is to utilize more and more of such equipment, some of which is quite complicated. There is a possibility that some equipment may be of faulty design, or the installation may not be made in a manner that permits of the best sanitary results being obtained. There are several possible defects to be avoided in milk-distributing plants and their equipment. In Ontario, specific requirements are set forth in the Milk Control Regulations.

Dairy Layout

The layout of a milk-distributing plant is the starting point for controlling possible defects. The Ontario regulations call for a separation of the processing room from bottle washing and other operations. The reason for this is obvious as milk processing should be carried on under the most sanitary conditions. To aid in this, the processing room must have self-closing doors, must not open directly off any residence or other building, and must have well-drained, impervious floors, and painted walls and ceiling. A light-coloured paint is recommended. An arrangement of this kind not only results in a suitable room for handling such an important food but it cannot fail to have a stimulating effect on the operator in his work, and promotes cleanliness at all times.

The minimum number of rooms in any milk-distributing plant is two, but for best results, especially in a larger dairy, more are desirable. It is not satisfactory to have the milk cans unloaded directly into the processing section. A separate milk-receiving room is recommended. Where this is not convenient, the cans may be taken into the wash room until they are carried individually to the pasteurizer, or until the milk is pumped into the vat. Many dairies have been found to be faulty in this respect, and many have been so overcrowded that efficient and sanitary work has been made difficult. The provision of suitable rooms for a dairy should be given every consideration and the attempt should not be made to carry on operations under adverse conditions.

The Pasteurizer

Defects in the design of the equipment for processing milk have been fairly numerous in the past. As more study has been given to these problems, many of these defects have been eliminated. Much old equipment is still in use, and this generally requires some alterations to meet the present requirements. The pasteurizing equipment is the centre of the dairy. Numerous defects have been found in these old installations, including leaks, inadequate insulation, foaming

and other difficulties with connections and accessories of the vats. Then, too, operators who are untrained or careless may permit conditions which are detrimental to the finished product.

Valves

The inlet and outlet valves on pasteurizing vats are sources of danger. Cold pockets may be found on the outlets of pasteurizers particularly in the older equipment. These pockets may permit milk to pass through the pasteurizer without being properly heated. A distinct menace exists under these conditions in that the first milk from the vat may contain dangerous organisms and these will contaminate the cooling equipment and this in turn infect the remainder of the milk. The arrangements should be such that the personal factor will play only a small part. The chief danger occurs when a number of vats are connected as one unit with single milk lines. Grooved inlet valves are available and they give satisfactory results. An additional safeguard is found where only a single inlet pipe-line is used regardless of the number of vats to be filled. This single connection is then moved from unit to unit.

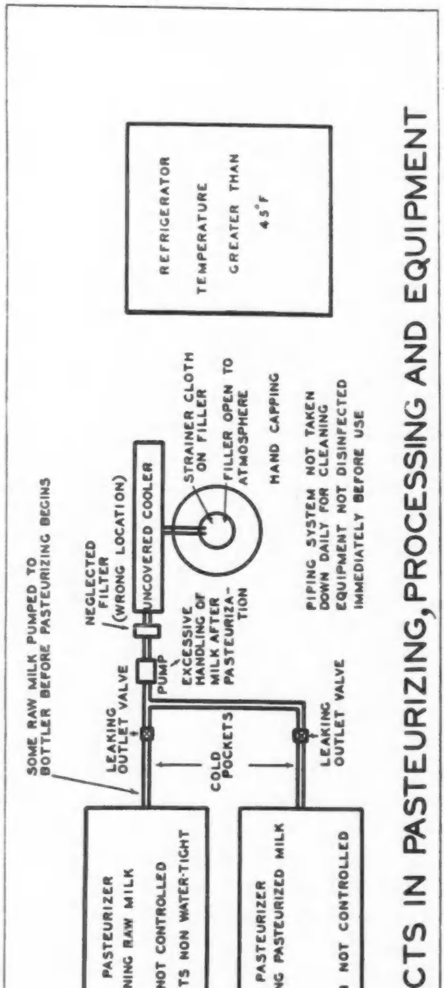
Outlet valves have been subjected to a number of alterations in design. When their weakness was first recognized, the type most commonly used was a barrel unit with steam and waste connections which opened automatically with the closing of the milk line. These were very safe valves when operated properly, but they were somewhat difficult to clean. The present practice has been to use grooved plug-valves set close to the vat. To be of value, these grooves must be carefully inserted. They must run the full length of the valve, and should be equivalent in size to a semi-circle of 3/16 inch diameter.

Thermometers

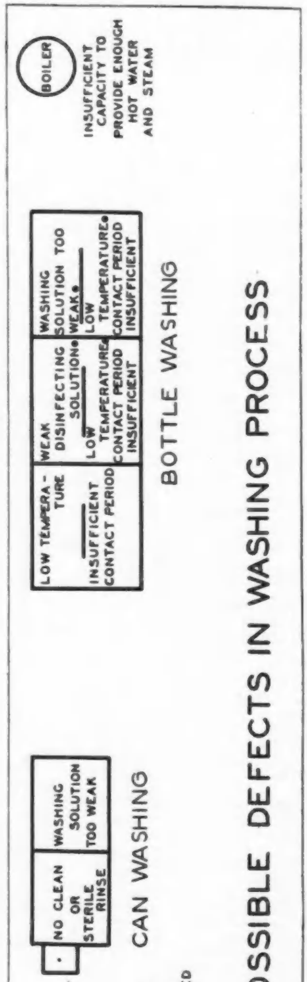
Modern practice calls for two thermometers on each pasteurizing vat, one being of the indicator type and the other a recorder using a 12-hour chart. These should be kept close together in the milk, and each should read in single degrees in the pasteurizing range. Experience shows that the recorders may get out of adjustment readily. Some have been found to be out as much as 15 degrees. For this reason it has been necessary to have these checked daily with the indicator, and a record made on the chart.

Piping

The danger from improper piping arrangements will be obvious where milk is handled. Complications of this nature have not been infrequent. Any piping system which allows raw milk and pasteurized milk to flow through even a very short section of the same pipe is dangerous. Only so-called sanitary piping should be employed in dairies. Every piping system and other demountable equipment with which milk comes in contact should be taken down daily for cleaning and disinfection. To fail to do this is very bad practice. The piping system should be given a further treatment with hot water or chlorine solution just before it is used. Numerous studies have shown the necessity for re-emphasizing the proper cleaning and sterilizing of the piping system.



POSSIBLE DEFECTS IN PASTEURIZING, PROCESSING AND EQUIPMENT



POSSIBLE DEFECTS IN WASHING PROCESS

Cooling Equipment

The operator of every pasteurizing plant should be impressed as strongly as possible with the necessity for avoiding contamination of the milk after it has been processed. For this reason cooling and bottling equipments call for special attention. The chief requirement for the cooler is that it shall be covered or placed in a small room used for this purpose only. If removable covers are used, they must protect the entire cooler.

Bottling Operations

The final part of the processing, involving bottling and capping, is an important one. Mechanical equipment is essential. Hand operations are no longer permitted or justified. With this equipment there is no call for any contamination of the product between the pasteurizer and the final package. It is handled virtually in a closed line.

The labelling of bottles has been recognized as important for the guidance of the purchaser. Every bottle must bear the name of the dairy in which the milk was processed, and must state whether it is pasteurized or raw. In Ontario raw and pasteurized milk are not permitted to be sold from the one dairy. The opportunity for contamination and confusion is too apparent to justify any other action.

Cleaning Operations

An important yet tedious and laborious task in every dairy is the daily cleaning operations. When ineffectively done, the bacteriological examination of the bottled pasteurized milk reveals the neglect. No single procedure is specified. The desired results can be accomplished in different ways, and the effect is more important than the procedure followed. It is recognized that some effective detergent or cleansing agent is necessary for removal of the milk solids. This must be followed with a bactericidal treatment for destruction of the remaining bacteria. Steam and hot water have been used extensively and when applied properly give excellent results. The trend at present is towards the use of chlorine compounds. When used on equipment free from milk film and in a concentration of about 100 p.p.m., very satisfactory results can be expected.

Operating Technique

It is essential that the operating procedure be such that safety and best results are assured. In Canada generally there are no regulations requiring the employment of trained operators. Inefficient operation is encountered in the cleaning of the utensils, piping, and equipment as well as in the conduct of pasteurization. Increasing attention is being given to the necessity of the training of operators.

EDITORIAL SECTION

THE VALUE OF PASTEURIZATION

PASTEURIZATION of milk prevents the development of all milk-borne diseases. In actual practice under Ontario conditions, wherever milk has been properly pasteurized there has been no record of any case of milk-borne disease. For instance, as a result of a study begun eleven years ago under the auspices of the National Research Council of Canada in co-operation with the Breeders Association of Canada and the Federal Department of Agriculture, and carried out in Ontario in connection with the medical and surgical divisions of the Hospital for Sick Children, Toronto, it was found that just under 10 per cent. of 490 tuberculous children suffered from the bovine type. Bovine tubercle bacilli were isolated from bones, joints, glands, kidneys, meninges, and other parts of the body. In every instance it was found that these children had been fed raw milk. In contrast to this, the records at the Hospital for Sick Children show that since compulsory pasteurization was introduced in the city of Toronto in 1915, not a single case of milk-borne tuberculosis (bovine tuberculosis) has occurred in children whose sole source of milk has been Toronto pasteurized milk.

In regard to the occurrence of epidemics in Canada of other milk-borne diseases, Canadian records in recent years show that milk-borne cases of typhoid fever, paratyphoid, scarlet fever and septic sore throat amounted to no less than 8.034, with 703 deaths. All of this could have been prevented by the use of pasteurized milk.

Even with the greatest care raw milk is not safe. Although the agricultural departments are doing a remarkably fine work in weeding out tuberculous and other diseased animals from Canadian herds, this still does not make milk safe. The careful control of the milk-producing cows is not sufficient. Septic sore throat, scarlet fever, and typhoid fever, for example, do not come from the cow but from the handlers of unbottled, unpasteurized milk. In regard to tuberculosis, even tuberculin-tested cows, although showing a negative test, have been found to develop the disease and produce tubercle bacilli in milk before the next routine tuberculin test was done. Living tubercle bacilli have actually been found in certified milk formerly produced under the requirements for certification in Toronto.

The question of any harmful effect of pasteurization on the food value of

milk can be answered by the following statements. These are the results of careful investigations by many eminent workers.

Pasteurization increases the ease of digestibility of the protein in milk.

Pasteurization does not affect the utilization of the minerals contained in milk.

Pasteurization reduces the vitamin B_1 content of milk by approximately 23 per cent., and the vitamin B_2 content by 14 per cent.

Vitamin C is present in milk in such small amounts that it is of no practical value.

The other vitamins, namely, A, D and E, are not affected.

It is thus evident that the only adverse effect of pasteurization of milk from the nutritive standpoint is the slight destruction of vitamins B_1 and B_2. This deficiency in pasteurized milk is not of importance as vitamins B_1 and B_2 are widely distributed in the foods ordinarily consumed.

By the passage of a compulsory act during the 1938 session of the Legislature of Ontario the Province assumes a unique position in the record of public health throughout the world. In the passing of this act, Ontario becomes the largest political area in the world possessing a comprehensive compulsory pasteurization law and it must be considered as a great tribute to the public sagacity and humanity of the Premier and his Cabinet in a supreme endeavour to alleviate the appalling loss of life and sickness caused by infected milk.—ALAN BROWN, M.D., F.R.C.P.(C.), *Physician-in-Chief, Hospital for Sick Children, Toronto.*

THE NEED FOR A CONTINUOUS EDUCATIONAL PROGRAM

IN view of the importance of pasteurization of milk as a means of reducing the incidence of milk-borne disease, it is surprising that its general application has been so slow. Pasteurization is a supremely important factor in the preservation of health but if the public fail to realize its importance it is for the same reason that people have been slow to accept the other proved facts of preventive medicine. Parents fail to have their children protected against smallpox and diphtheria, and there are thousands of deaths as a result. The real fault, however, is not that of the parents. No normal parent would fail to utilize every possible preventive. But where the health authority fails to emphasize the importance of specific preventives in such a way that knowledge becomes widespread, parents, though they are more interested than anyone else, fail to act. Scientific knowledge locked up in laboratory files or in the minds or textbooks of conscientious scientific workers is useless. Knowledge is of value only when it is applied.

This is true with reference to pasteurization of milk. A vast amount of information has been compiled concerning the value of pasteurization. The value of pasteurization as a means of eliminating milk-borne tuberculosis, typhoid fever, undulant fever and other infections, and reducing infant mortality, has been absolutely proved. Equally well known is the fact that pasteurization has no material effect on the nutritive value of milk. These facts have been dis-

cussed repeatedly by health officers and physicians—and in this group there is no need for education. Medical associations and public health workers all over the world have endorsed pasteurization as an essential measure in all programs for the conservation of health and the reduction of mortality rates.

If medicine and public health opinion has not sufficiently impressed the public to cause the immediate adoption of compulsory pasteurization everywhere, the fault lies in the failure of the public health authorities to realize the necessity of intensive and continuous programs of public health education. If this is neglected, not only will the application of general pasteurization fail but health programs generally will fall short of success.

Recently the Government of Ontario has introduced a compulsory pasteurization law. In spite of the fact that an educational program has been in progress in the Province for several years, it was expected that the bill would meet considerable opposition, especially from rural members. Opposition did develop at the second reading of the bill. The Government then arranged for a number of physicians whose opinion was considered authoritative to meet the Committee on Agriculture. The physicians reviewed the established facts, with the result that the rural members who had previously opposed the bill without exception reversed their position. The bill was reported to the House unanimously and was passed without opposition. This was a remarkable demonstration of rapid public health education from which public health authorities might well learn a lesson. It is of interest that the members of the Committee on Agriculture recommended that the Government carry on a continuous program of education throughout the Province in order that all the people, especially in rural areas, may realize the significance of pasteurization, and take advantage of its benefits as rapidly as possible. A well-organized Canadian educational program is essential if pasteurization is soon to become generally effective in Canada.—GORDON BATES, M.B., *General Director, The Health League of Canada, Toronto.*